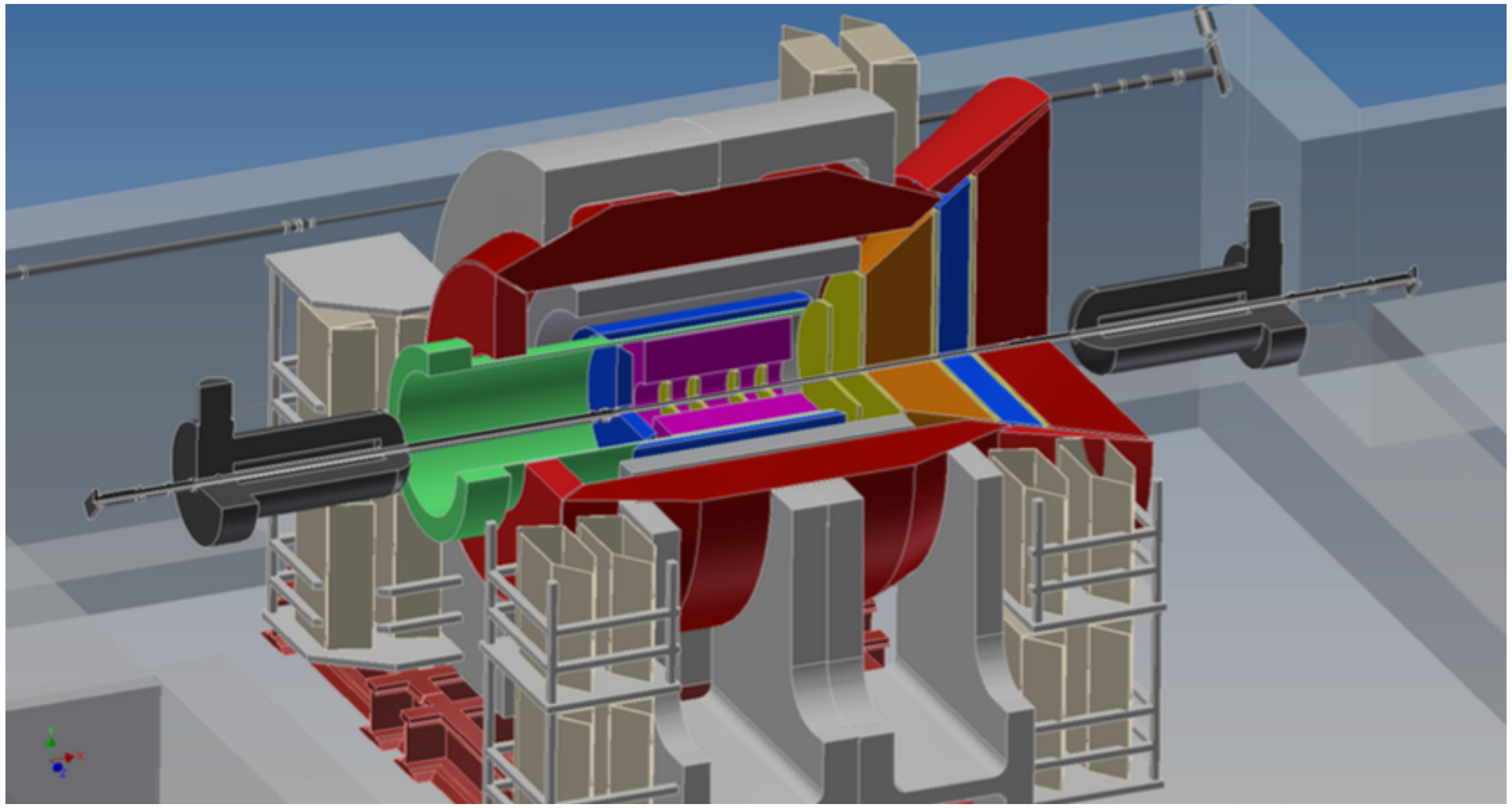
Stony Brook University

Conceptual Design for an EIC Detector Built Around the BaBar Solenoid

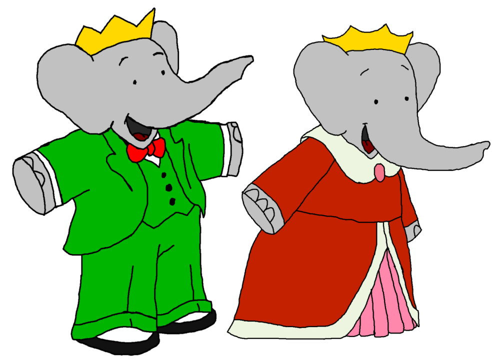


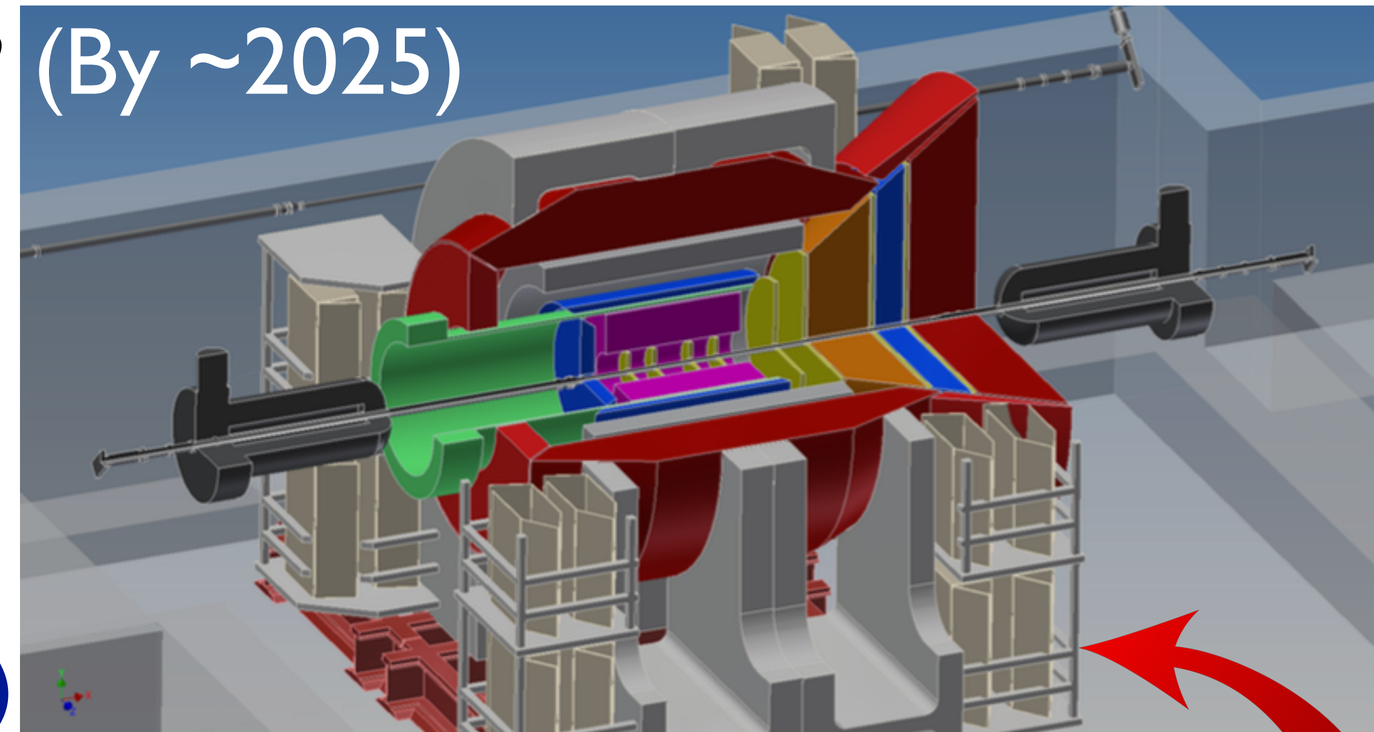
Nils Feege

Workshop for ‘A Large-Acceptance Jet and Upsilon Detector for RHIC’
held at Brookhaven National Laboratory on June 16 2015

Evolution towards an EIC Detector

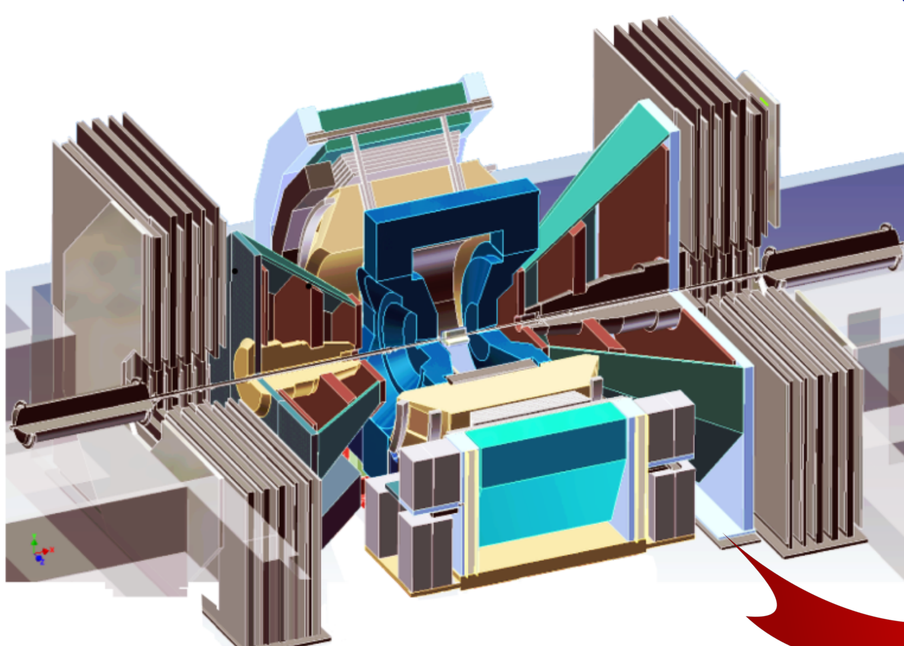
'CELESTE'?

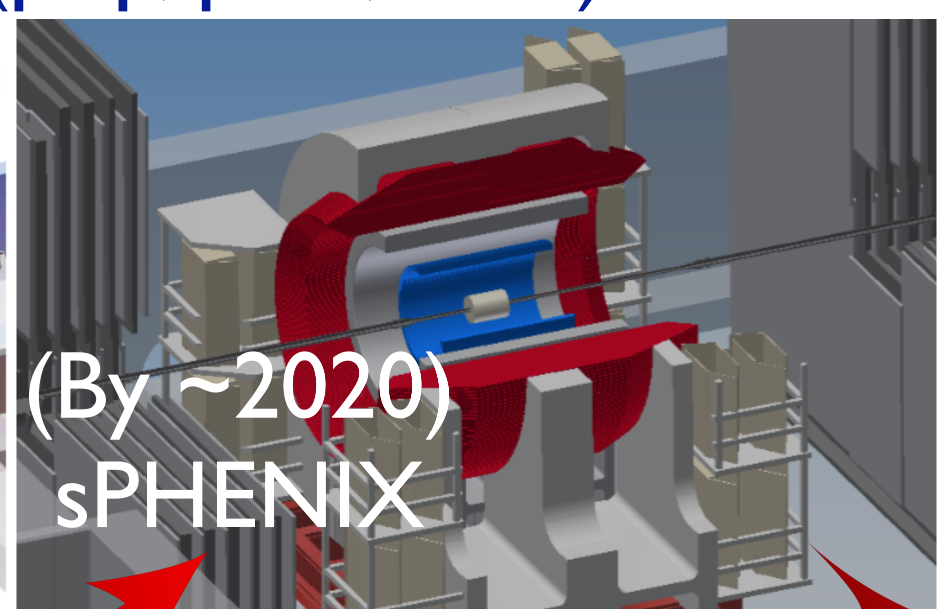


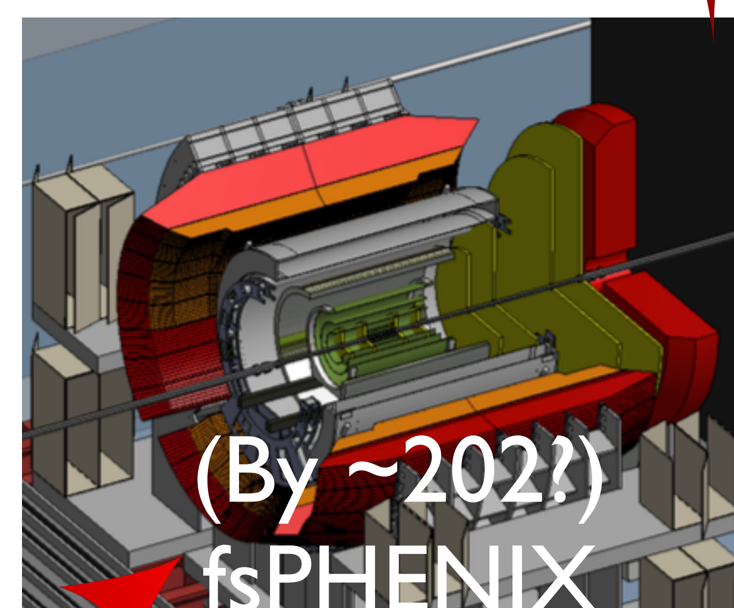


eRHIC (e+p, e+A)

RHIC (p+p, p+A, A+A)





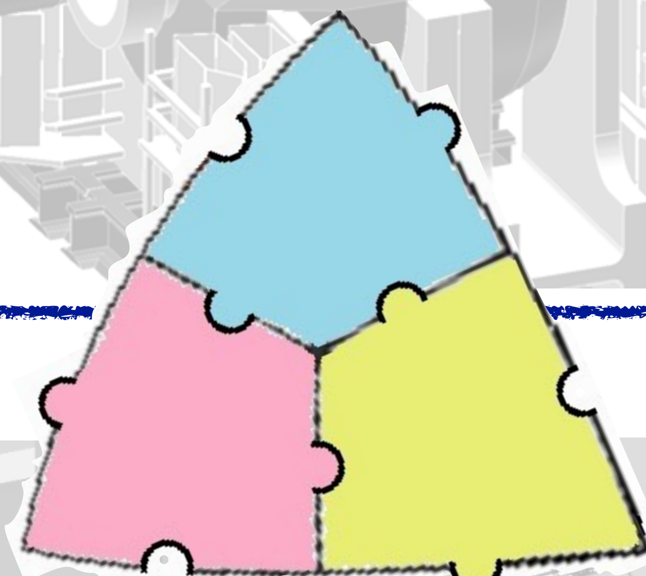


Putting The Pieces Together

- Nucleon spin and 3D structure
- Effects of ‘cold’ nuclear matter
- Color Glass Condensate

eRHIC (e+p, e+A)

RHIC (p+p, p+A, A+A)



- Quark-gluon plasma
- Effects of ‘hot’ nuclear matter

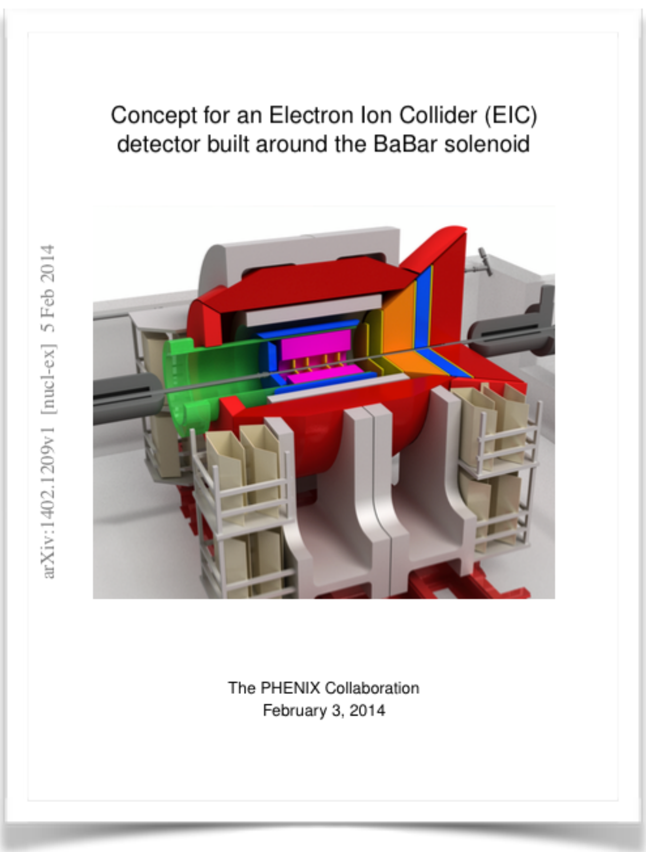
- Transverse spin
- Effects of ‘cold’ nuclear matter

Setting The Stage for the LOI Studies

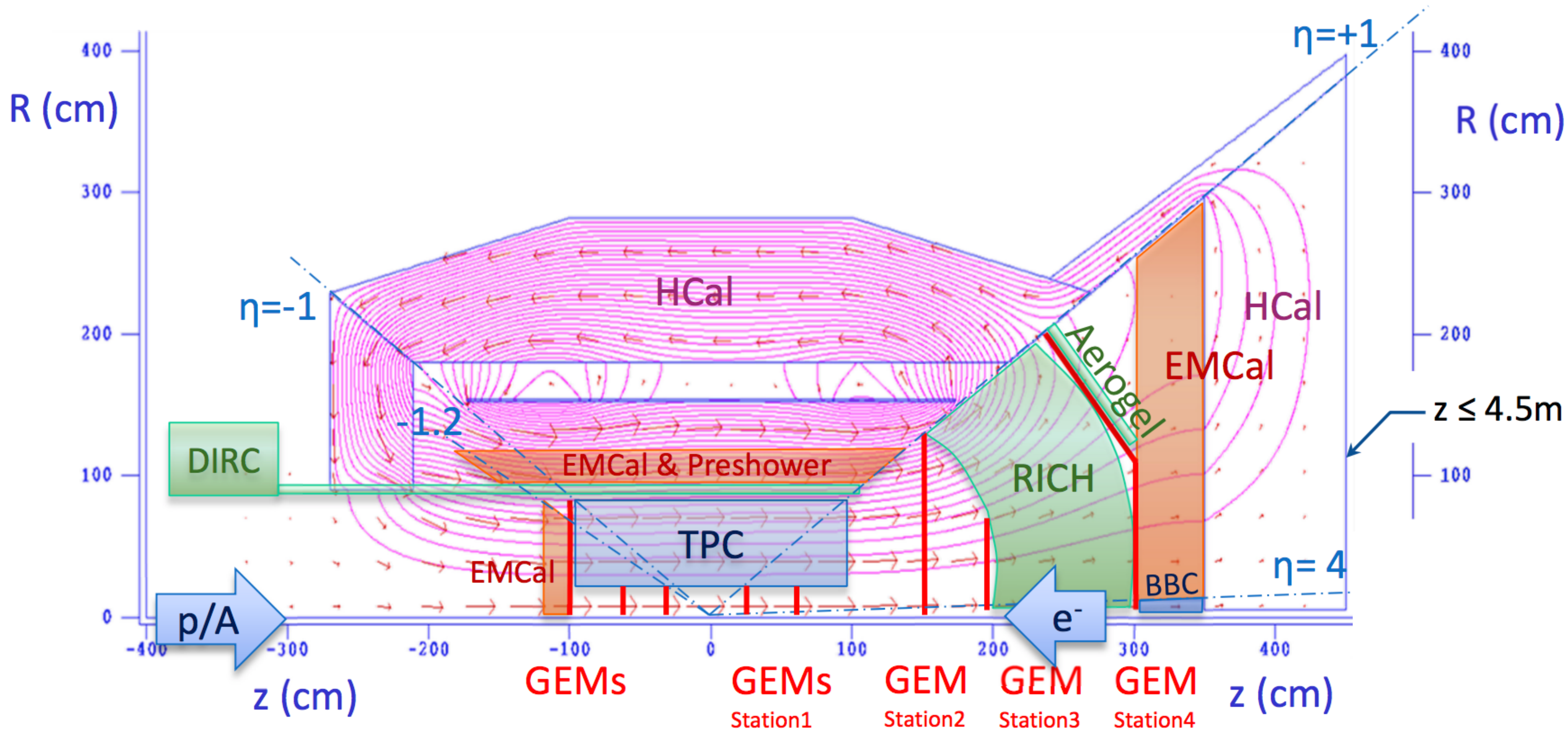
Maximum beam energies

e	10 GeV
p	255 GeV
Au	100 GeV / nucleon

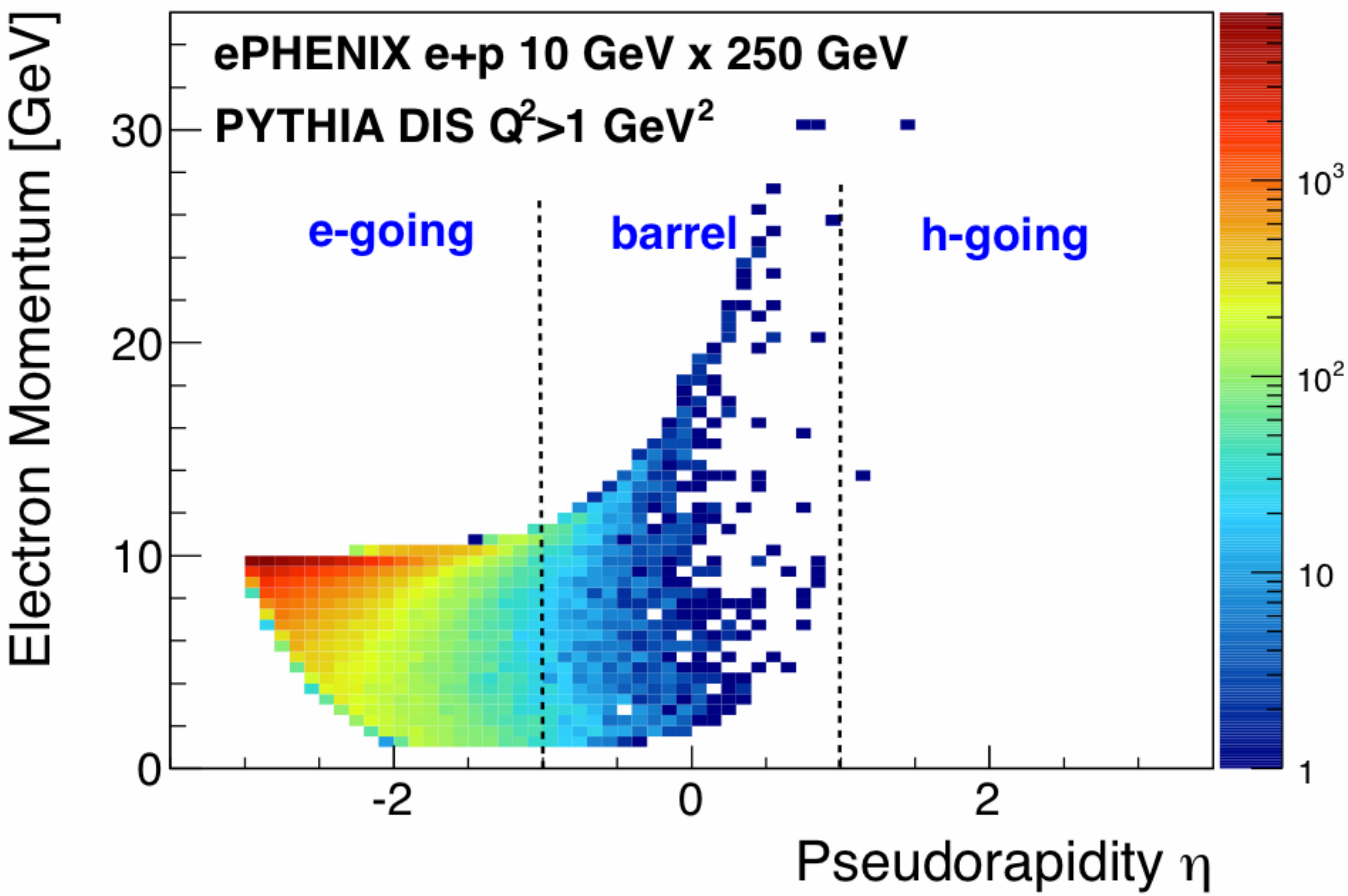
e+p Design luminosity (10 GeV on 255 GeV)
10^{33} cm^{-2}s^{-1}

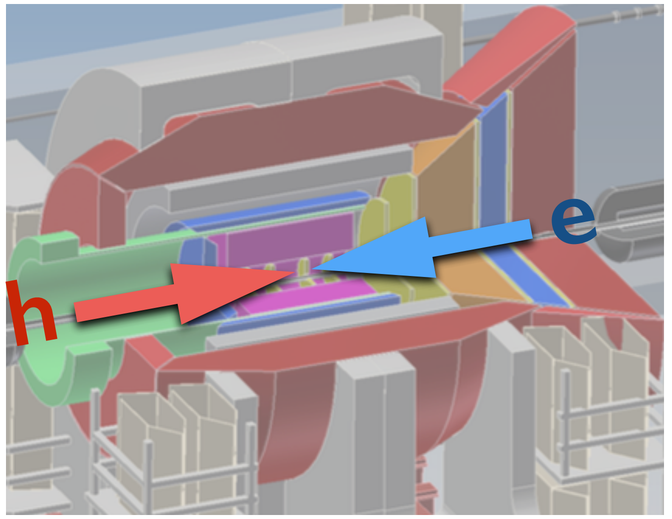


[arXiv:1402.1209v1]



DIS Electron Measurement



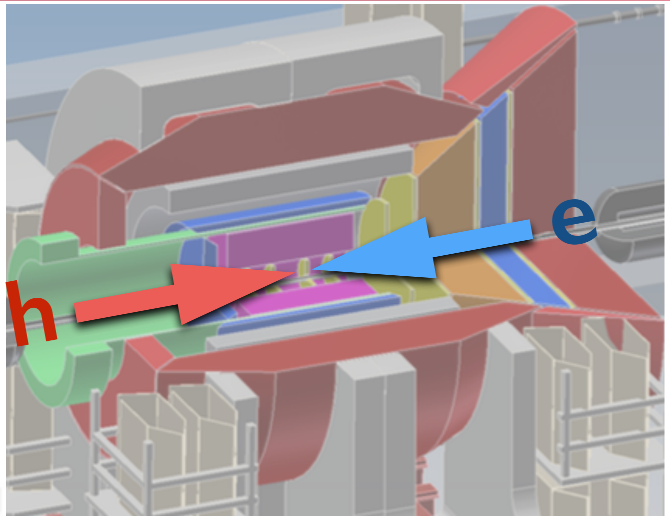


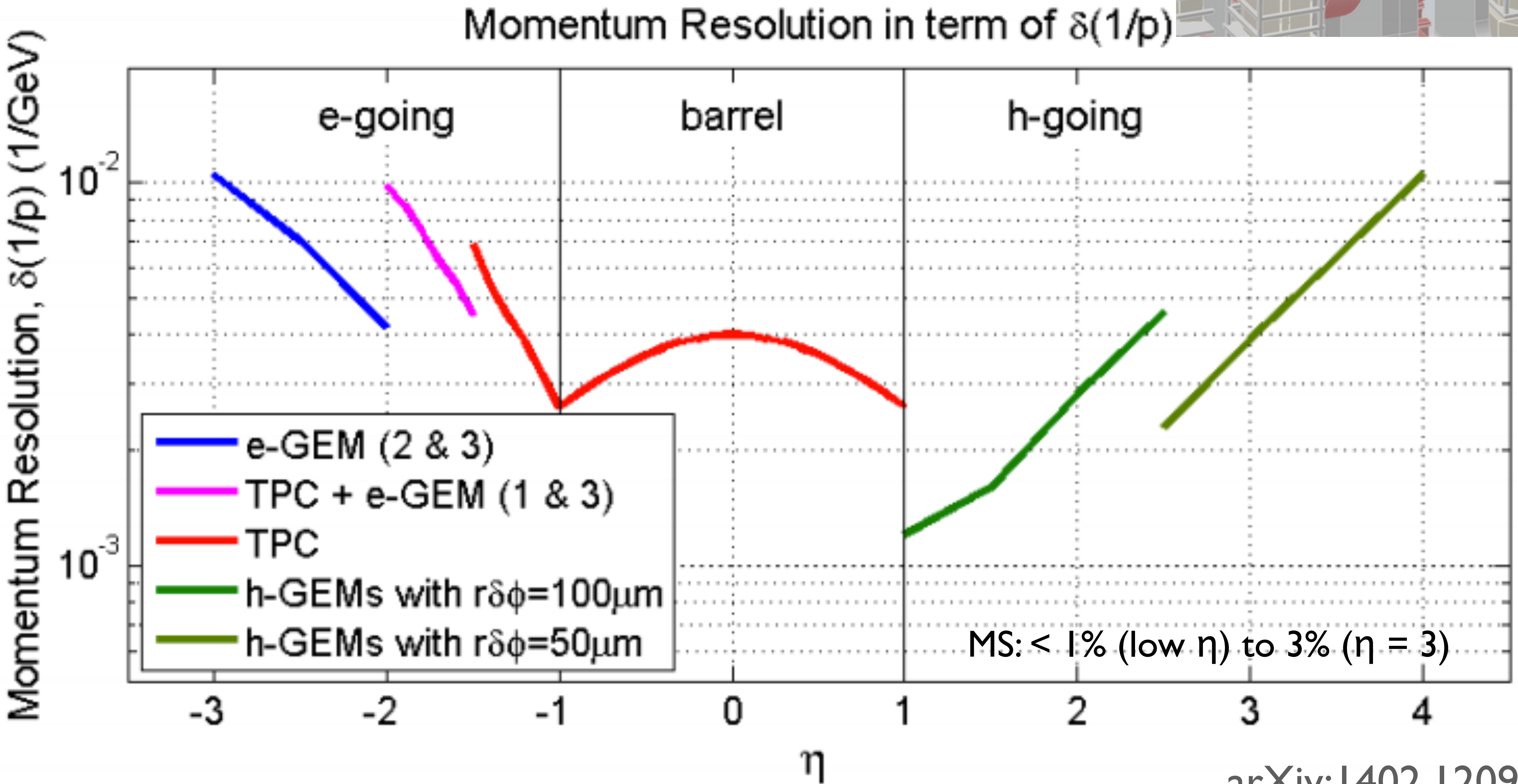
Need:
- Electron ID
- energy
- angle

Solution:
- ✓Tracking
- ✓Calorimeter

arXiv:1402.1209v1

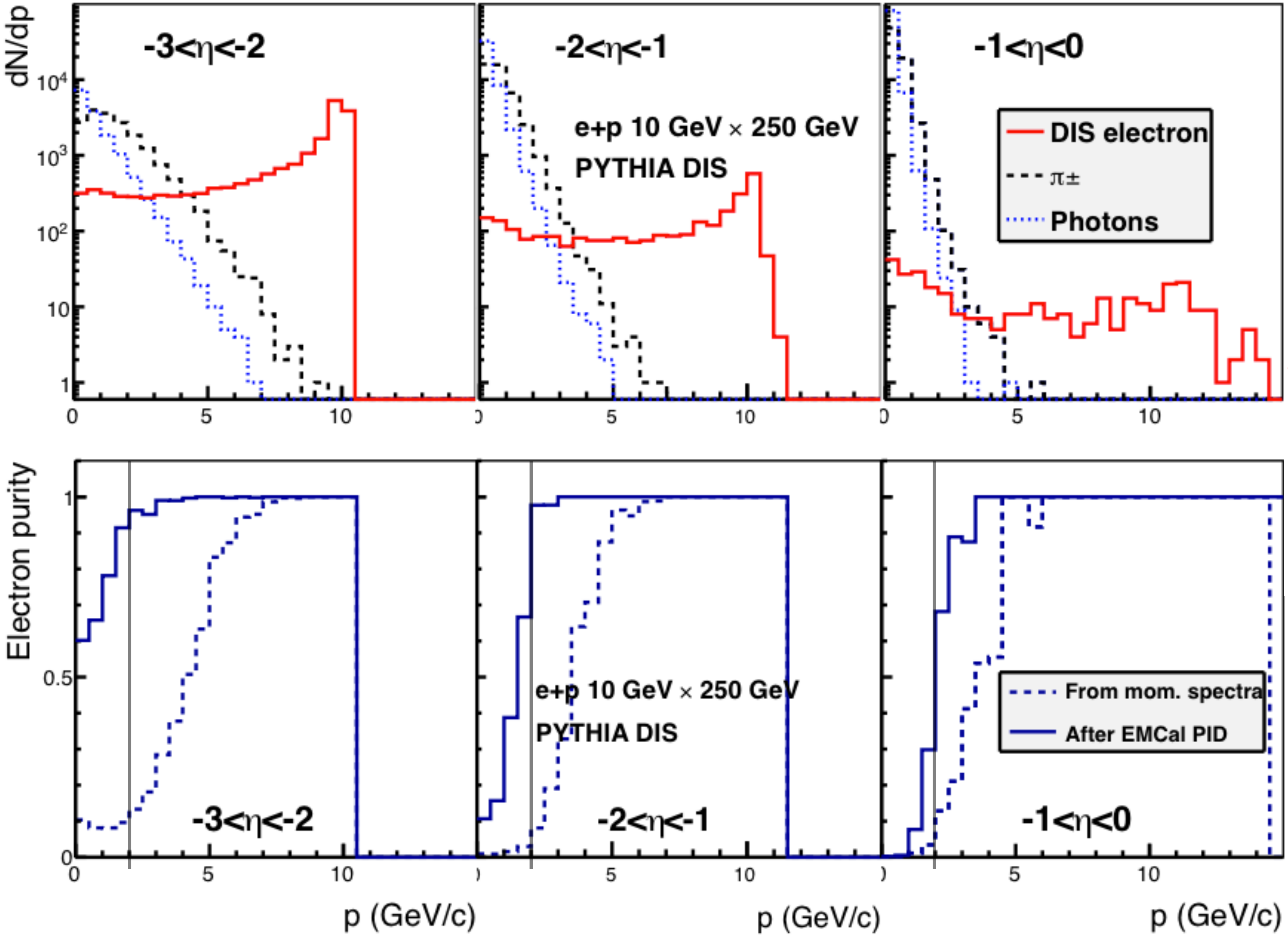
Tracking Resolution

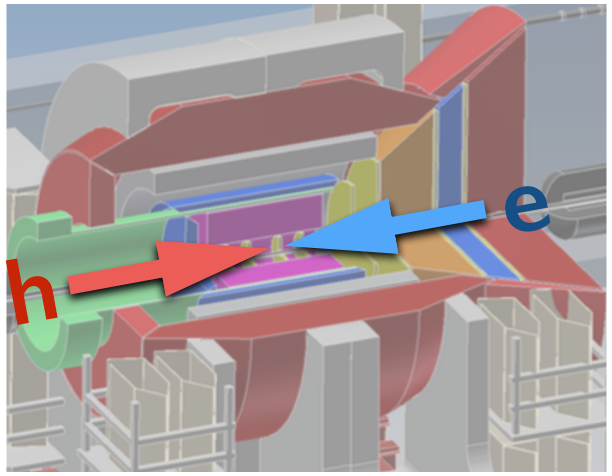


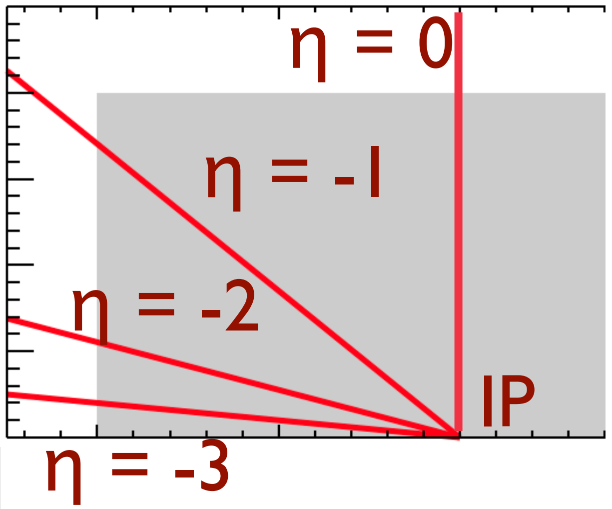


arXiv:1402.1209v1

Electron ID via E/p matching







2 Calorimeter:

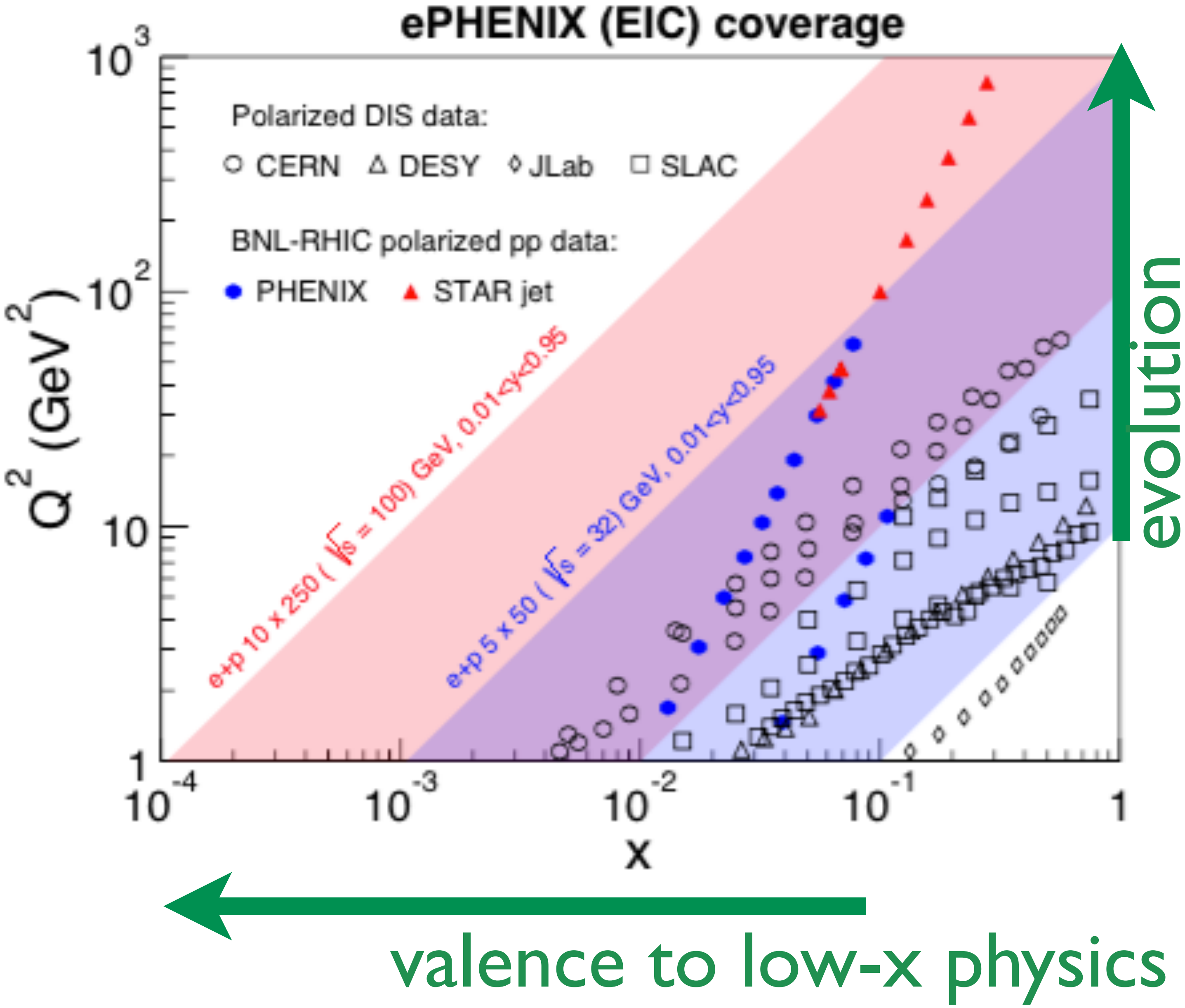
$\sigma_E/E = 1.5\%/\sqrt{E}$

$\sigma_E/E = 12\%/\sqrt{E}$

arXiv:1402.1209v1

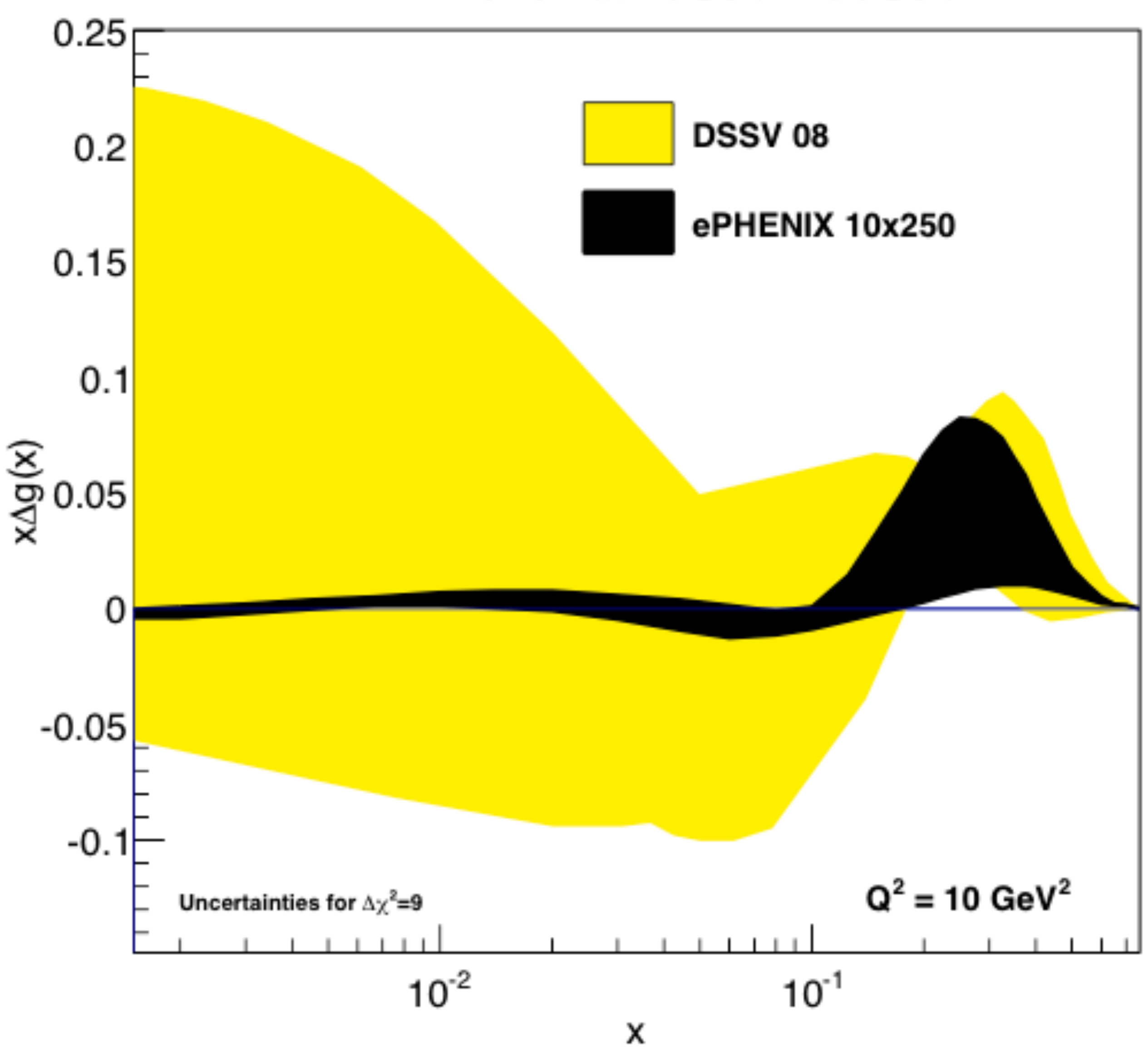
Proton Structure: Longitudinal Spin

$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + L_q + \Delta G + L_g$$



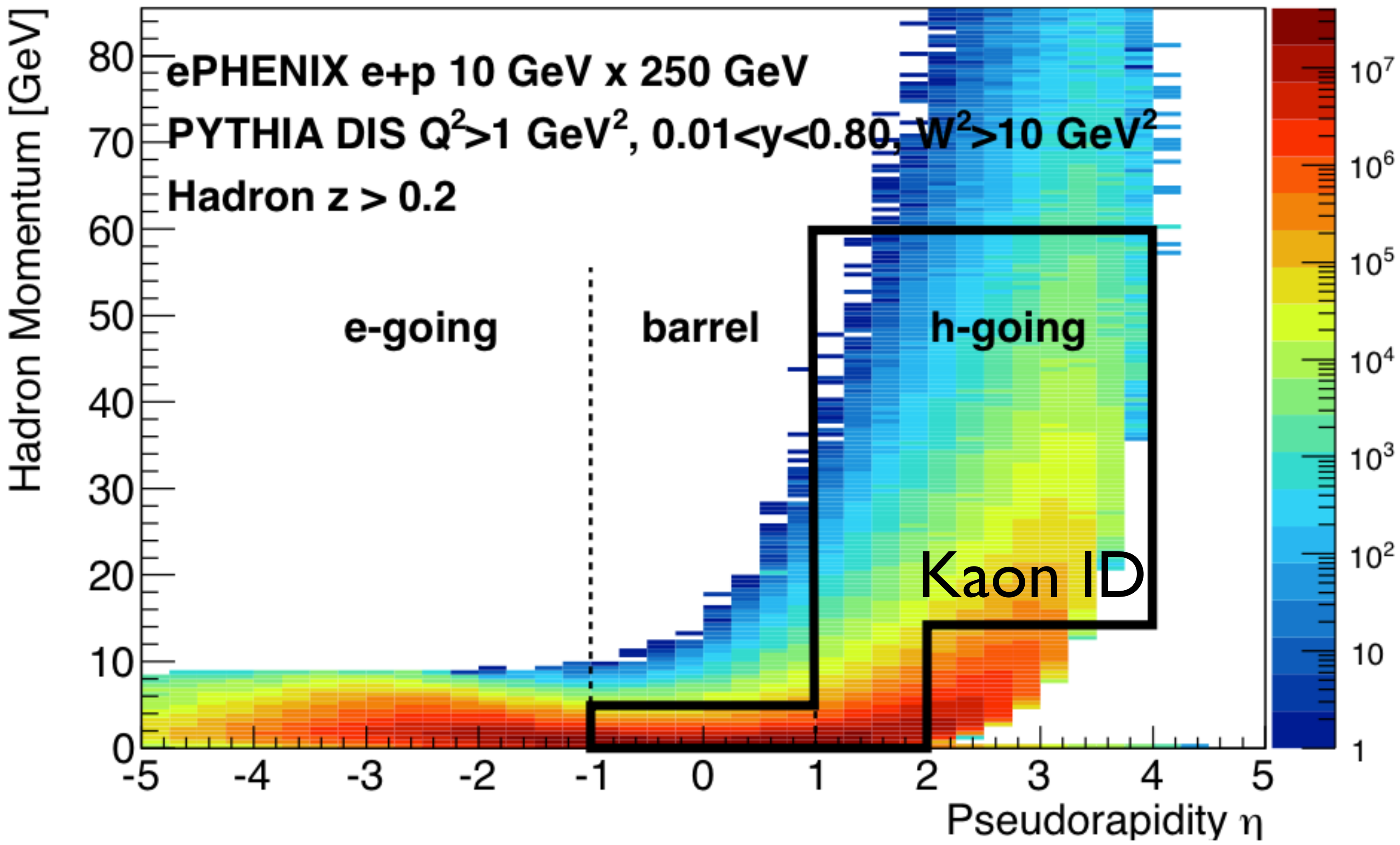
PHYTHIA generator and ePHENIX acceptance/efficiencies

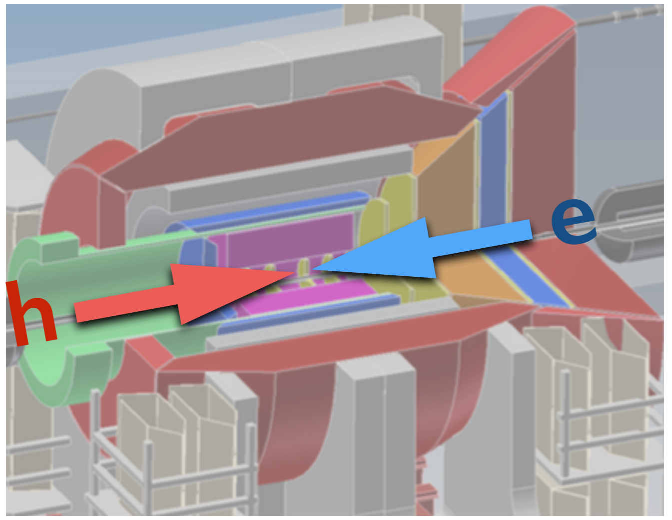
10 fb^{-1} at 10GeV×250GeV



arXiv:1402.1209v1

SIDIS: Hadrons from DIS Events



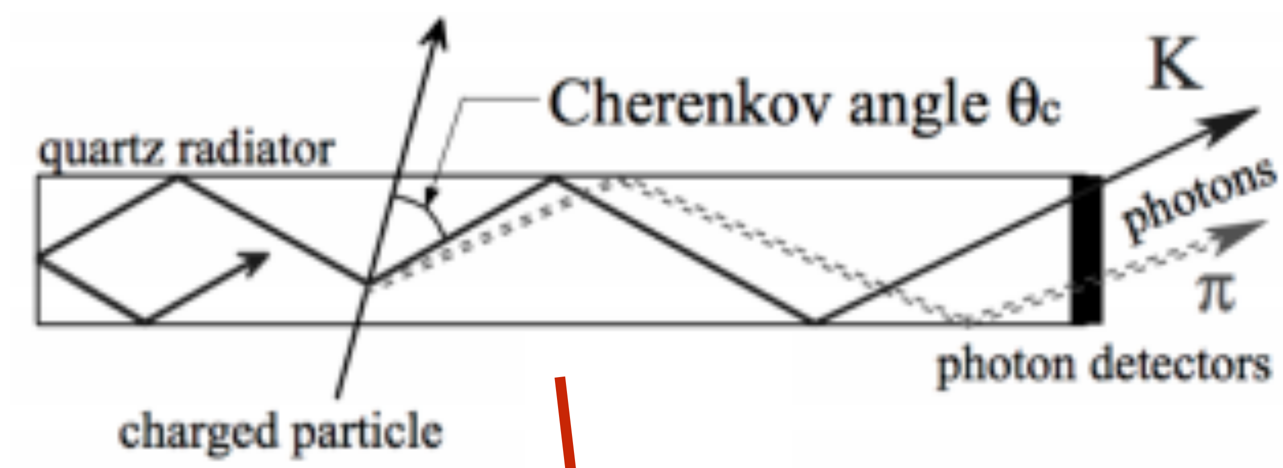


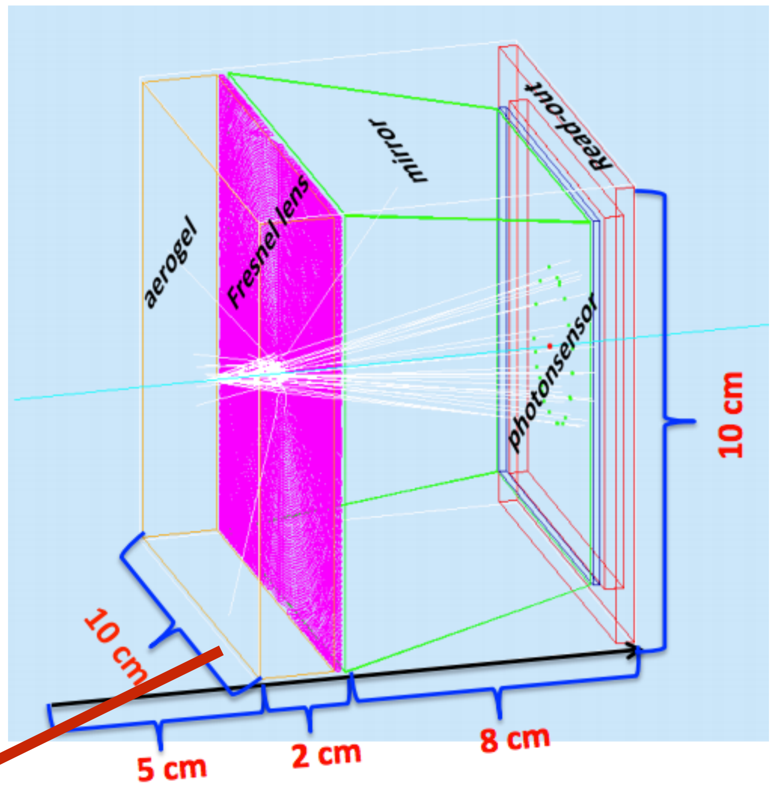
Need:
- Hadron ID

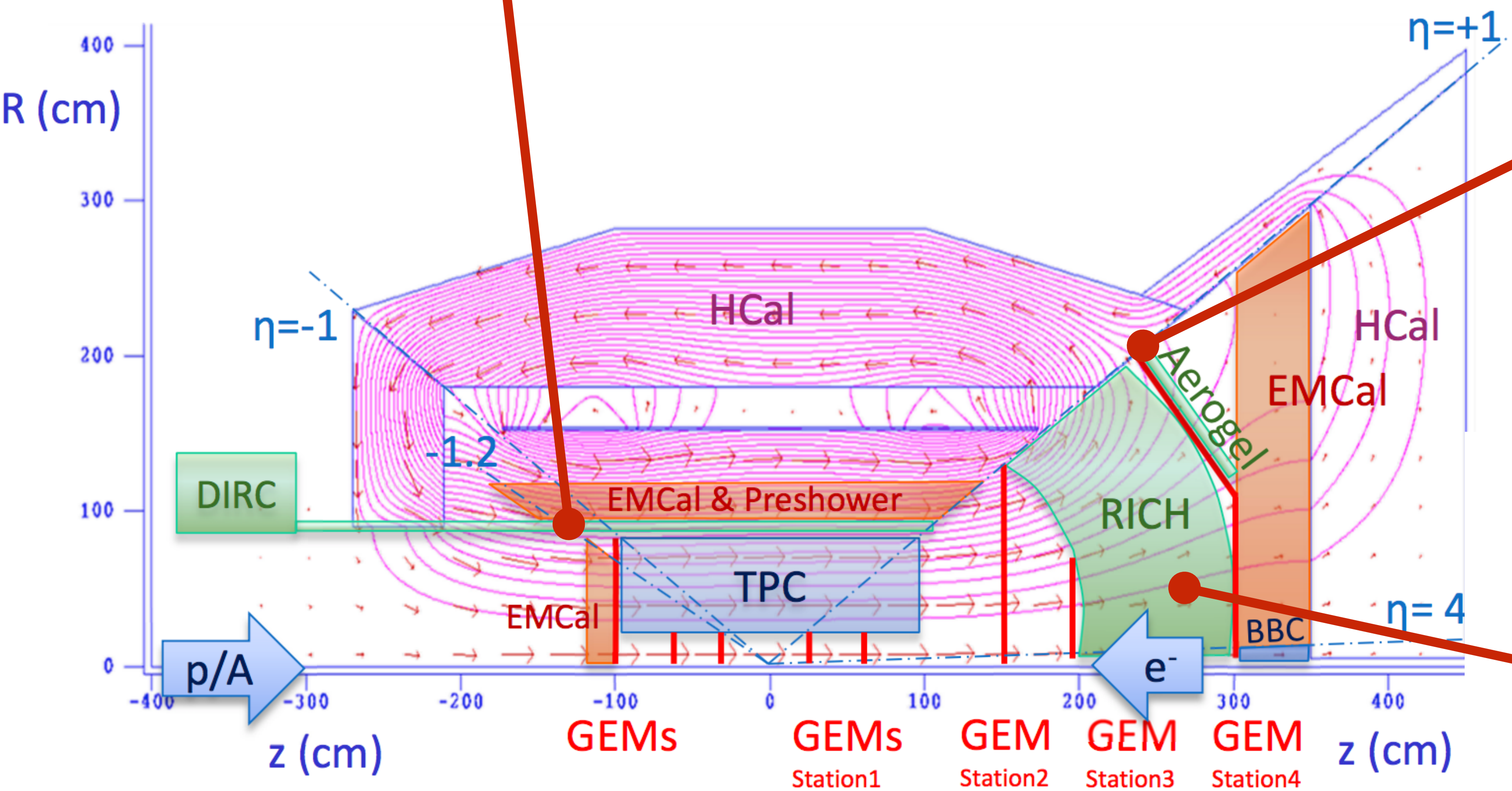
Solution:
- ✓RICH

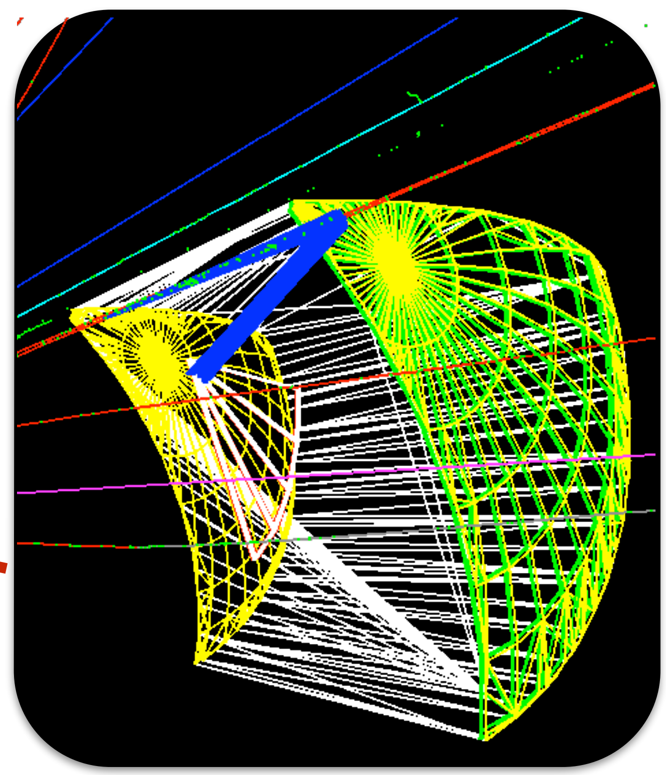
arXiv:1402.1209v1

RICH Detectors for EIC Hadron ID





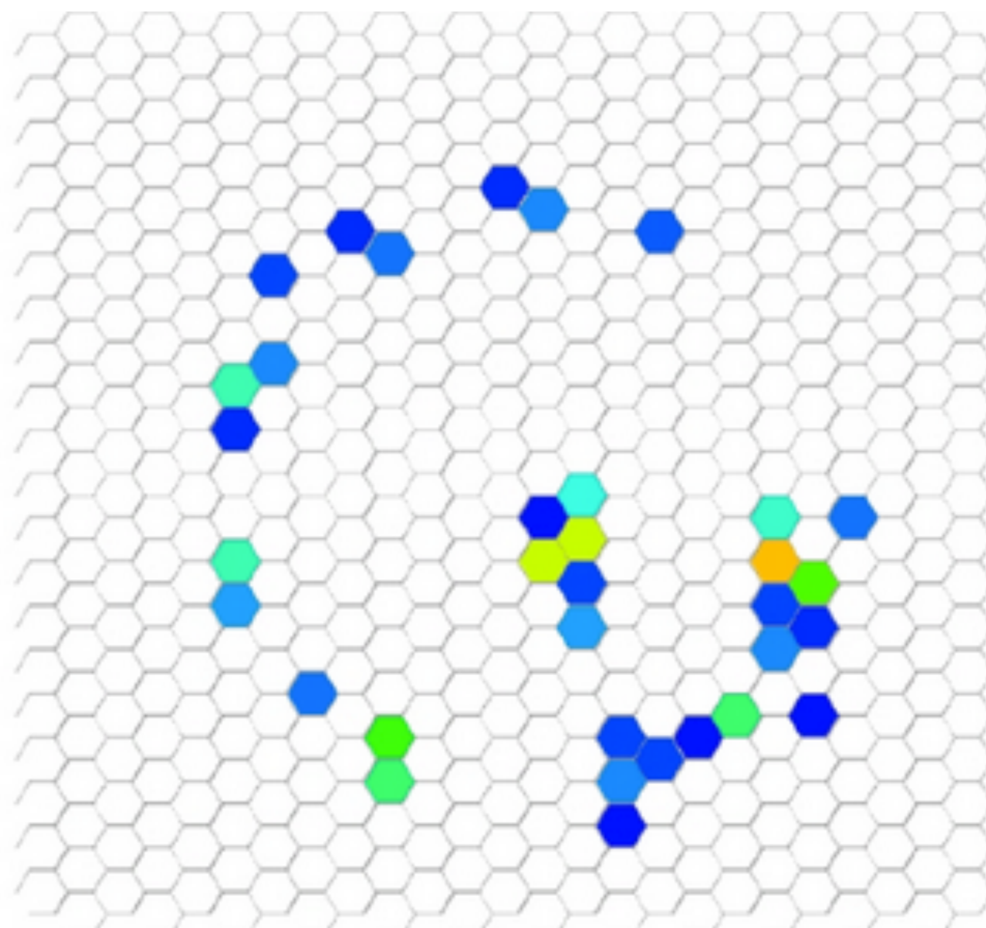


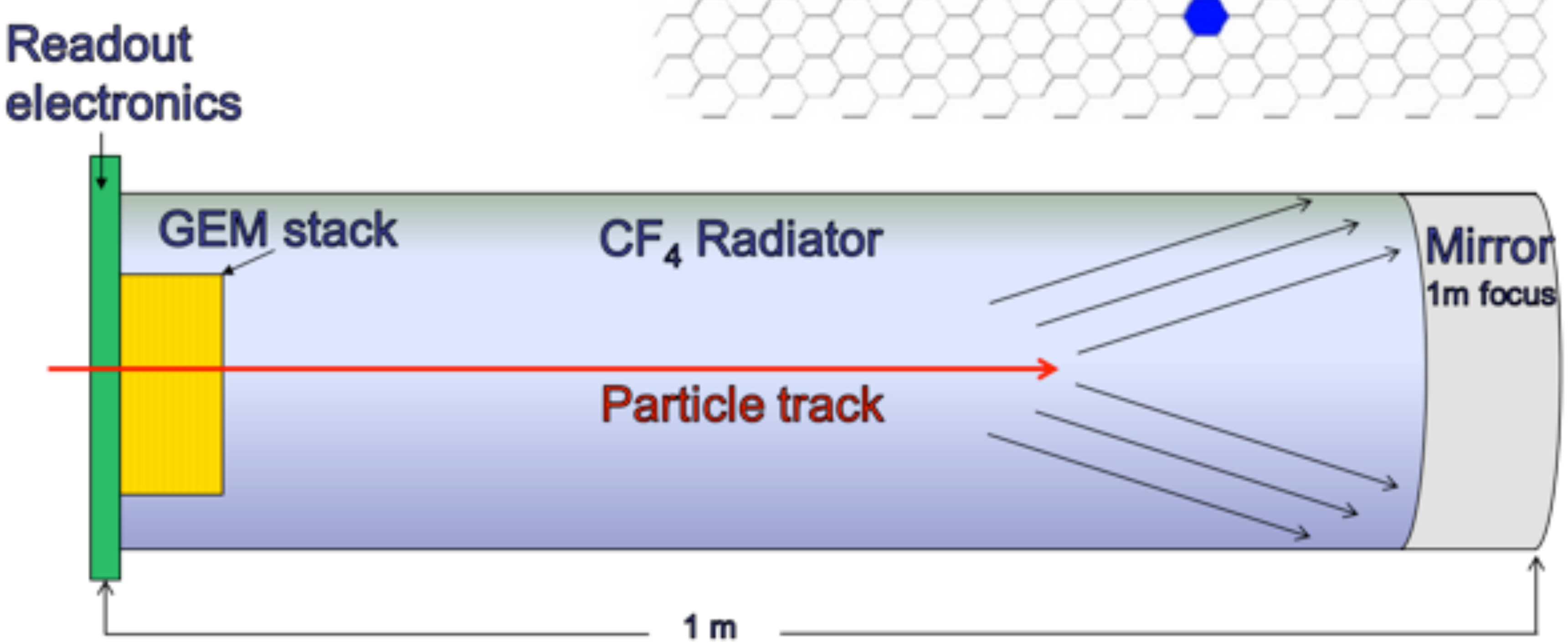


EIC R&D: Gas RICH

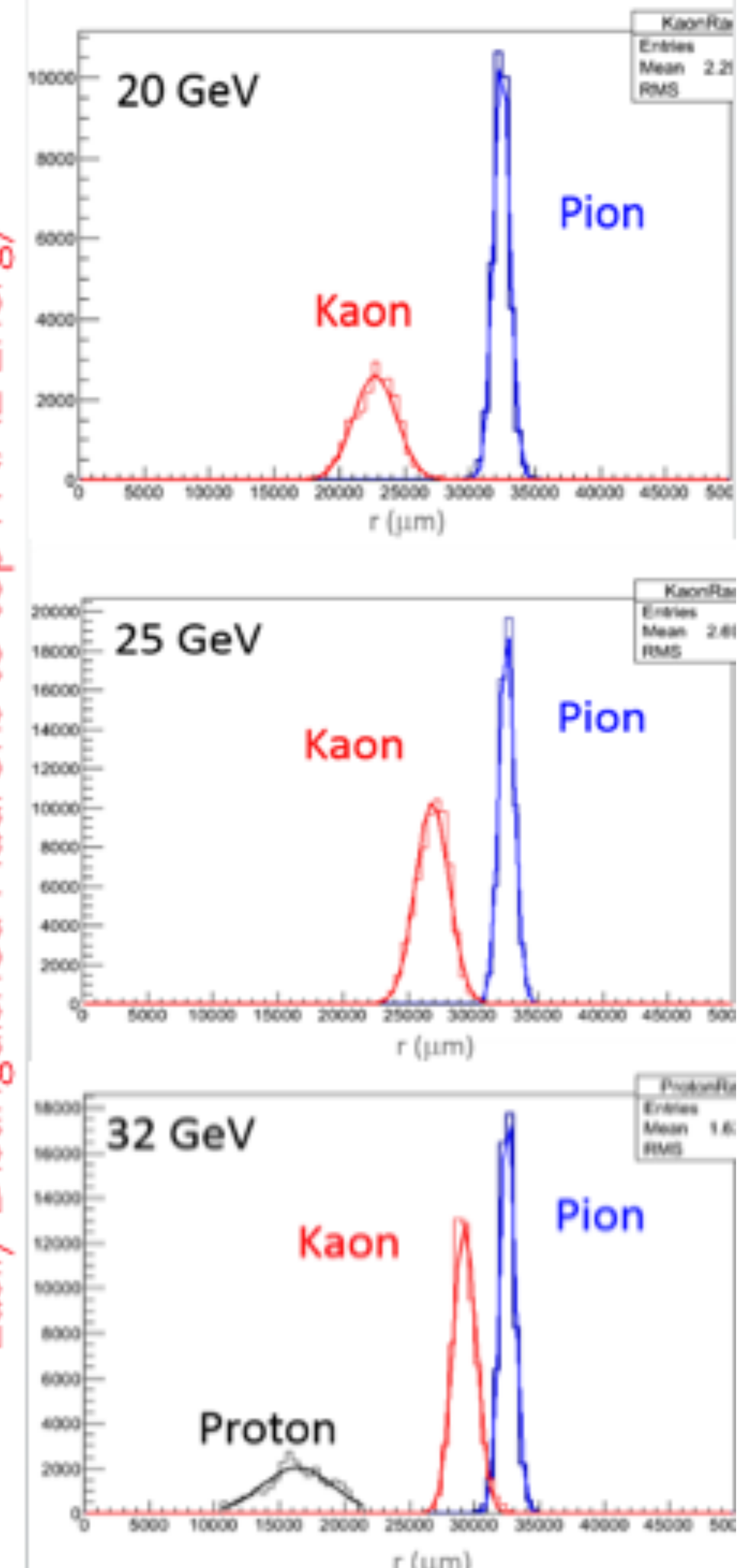
EIC R&D project eRD6

SBU Students:
Thomas Videbaek
Stefanie Zajac
Marie Blatnik
and others

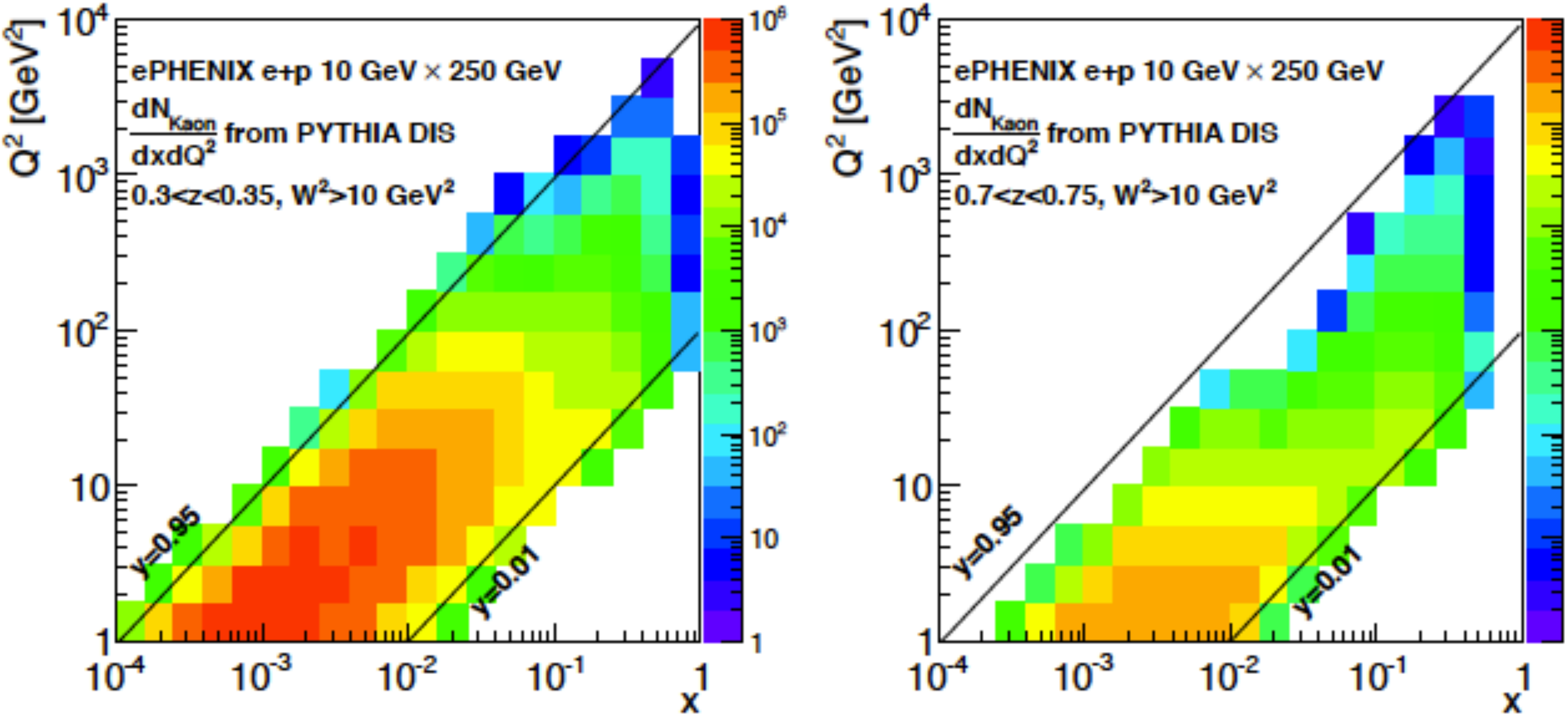




Easily Distinguished Hadrons to top FNAL Energy

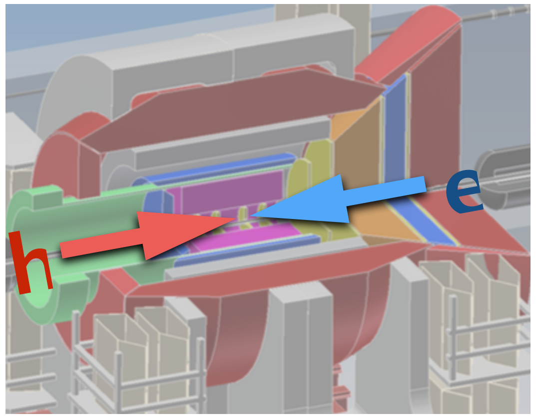


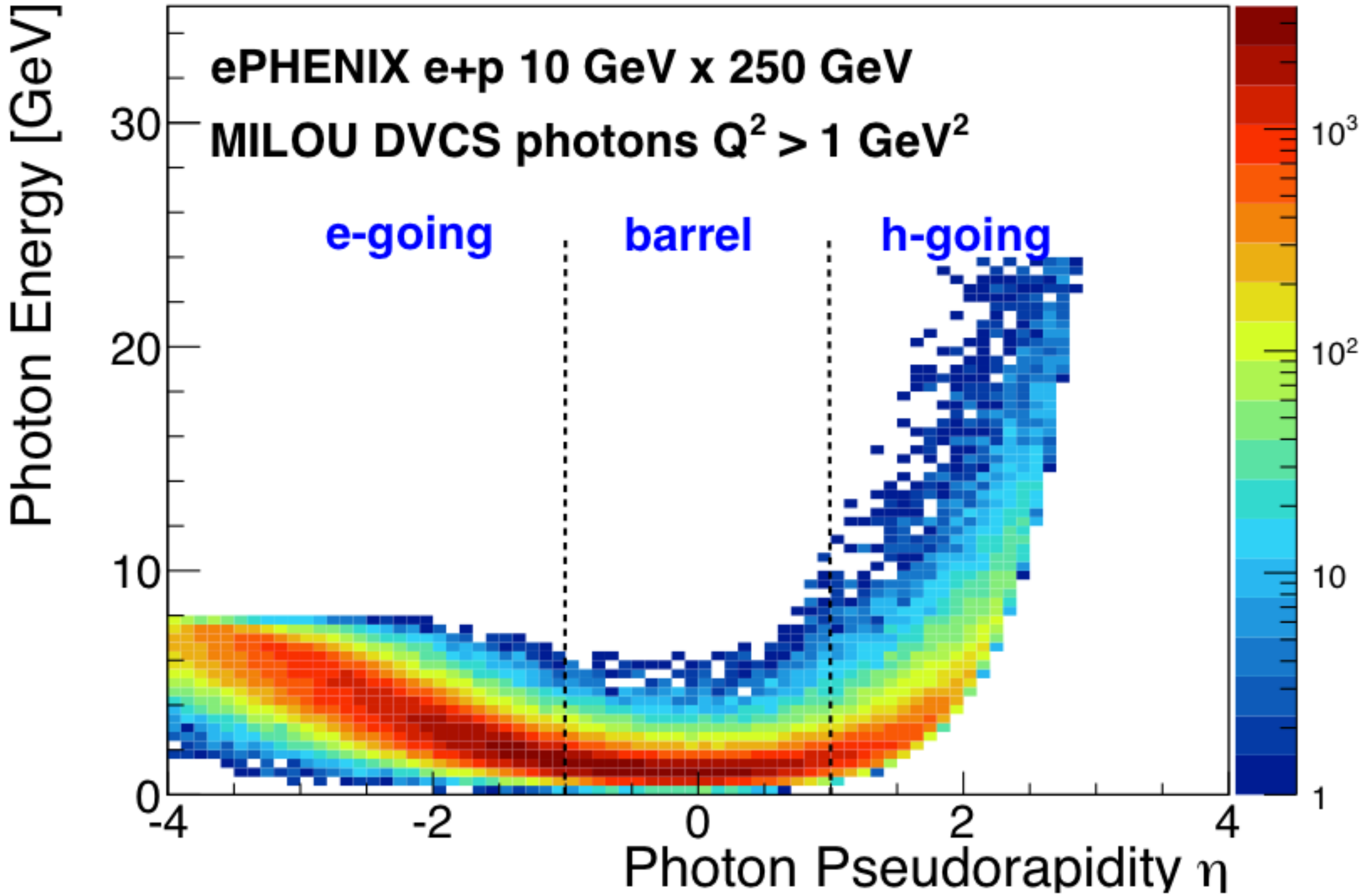
Kaon ID / Acceptance / Kinematics



arXiv:1402.1209v1

DVCS Photons





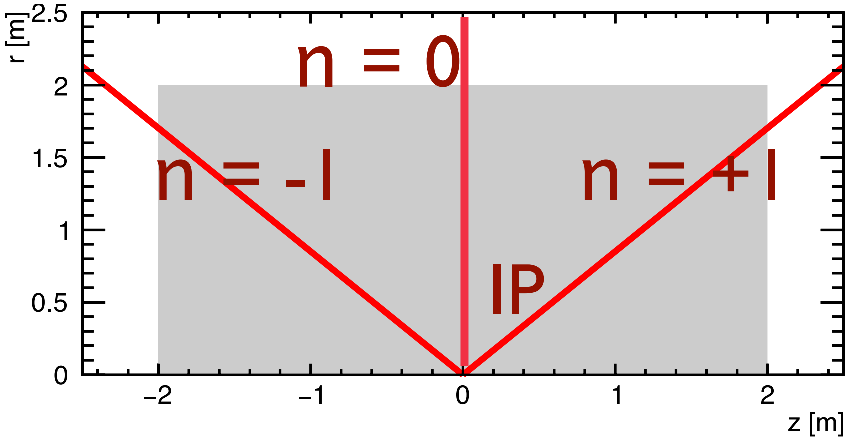
arXiv:1402.1209v1

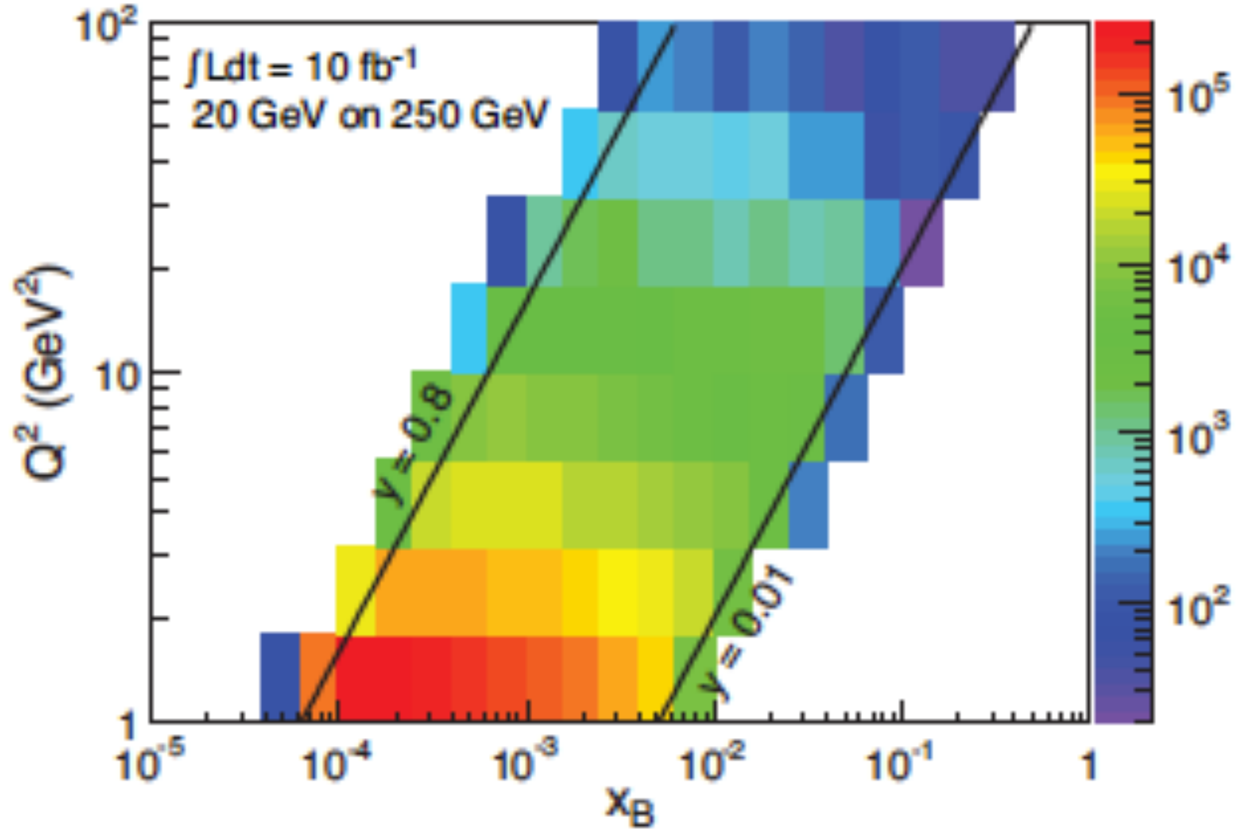
Need:
- Electron / photon separation
- Confirm exclusiveness

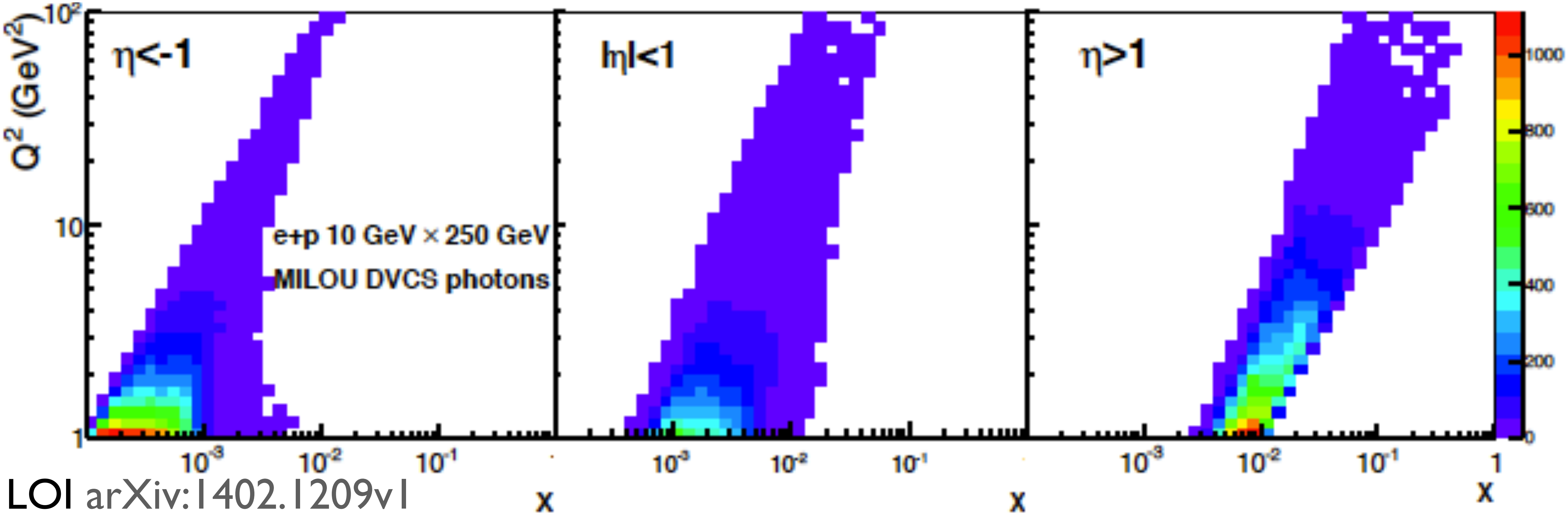
Solution:
- ✓Granular EMCal
- ✓Roman Pots (ZDC for eA)

DVCS Photon Acceptance

EIC WhitePaper arXiv:1212.1701v3



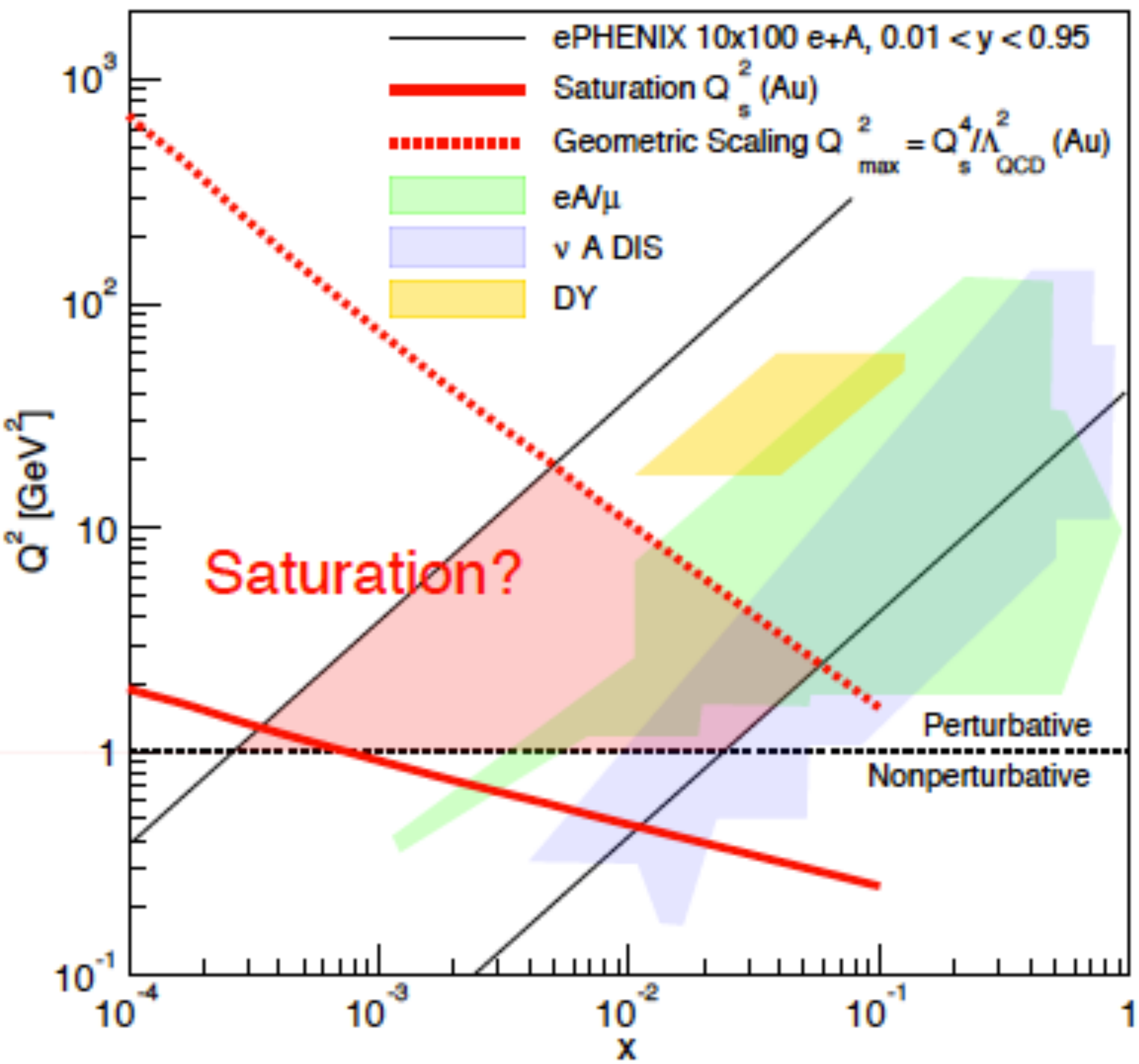


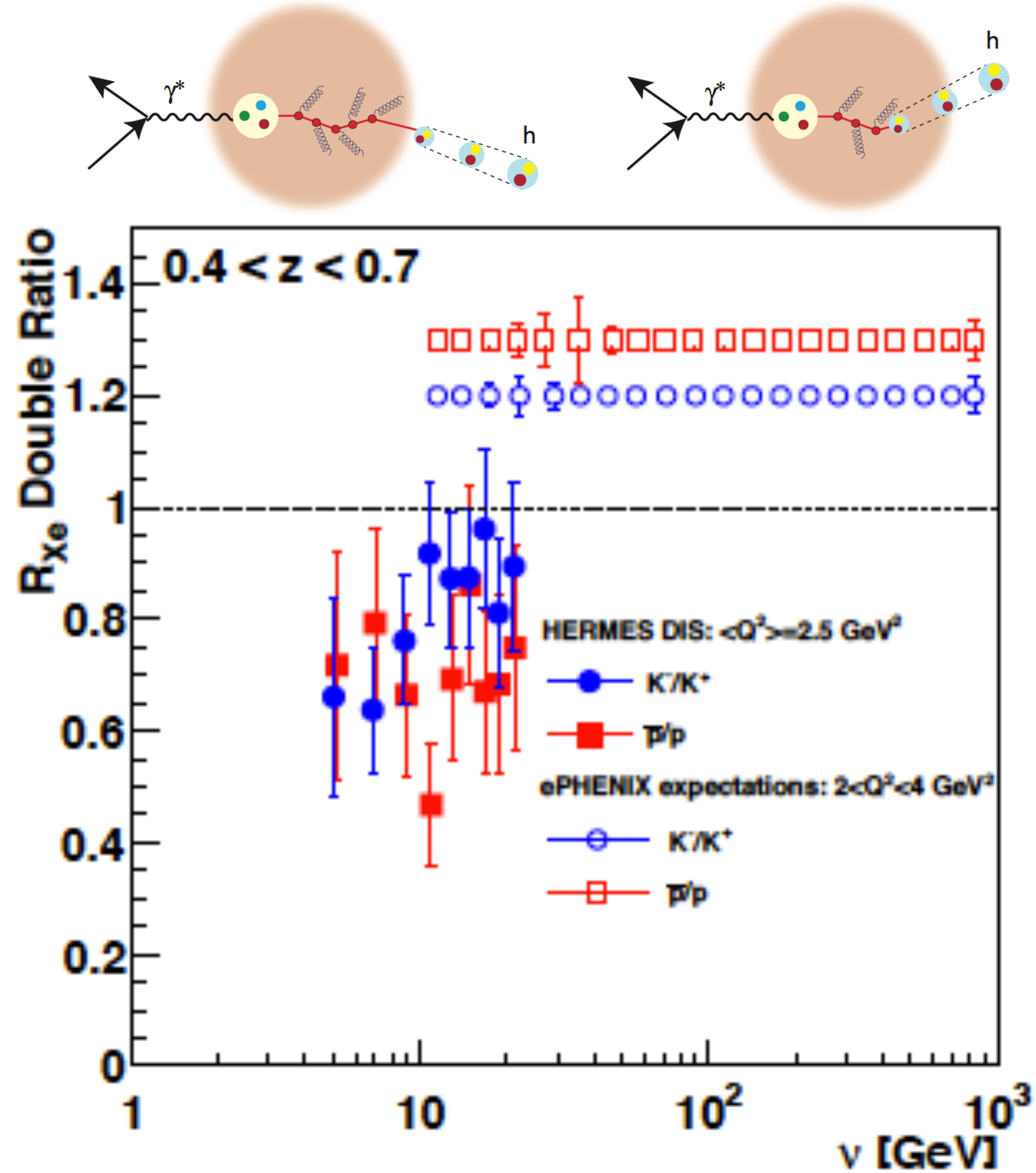


LOI arXiv:1402.1209v1

e+A Physics Opportunities

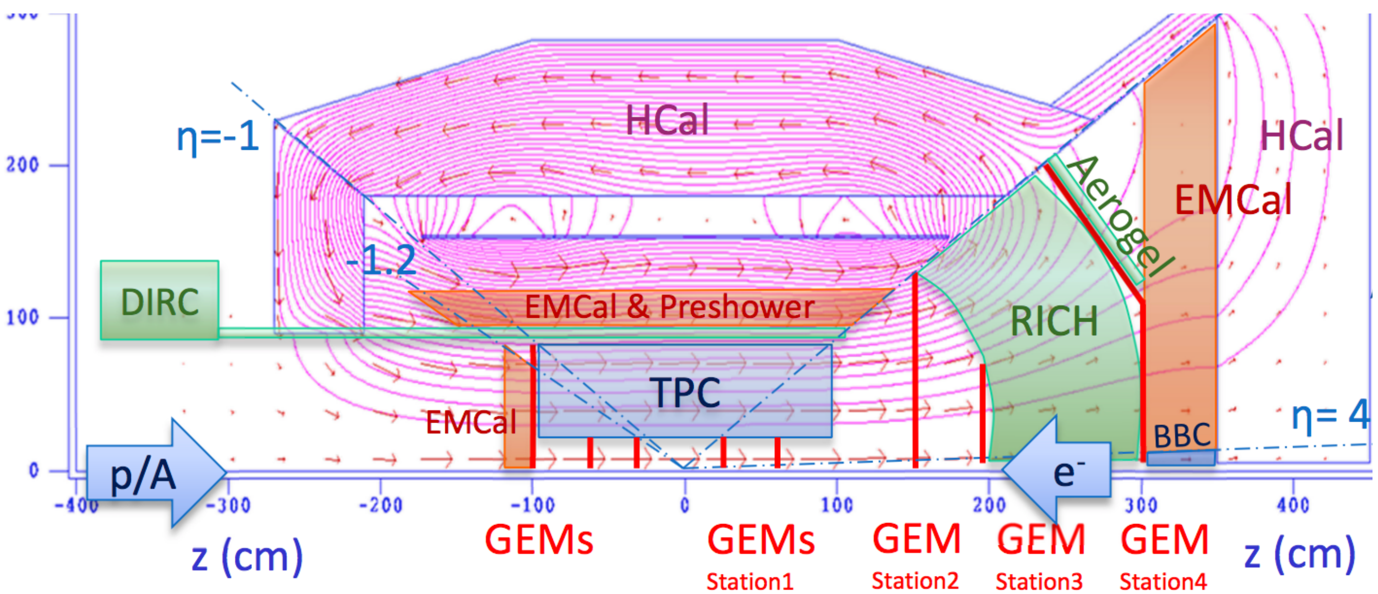
$$Q_s^2(x) \propto \left(\frac{A}{x}\right)^{1/3}$$

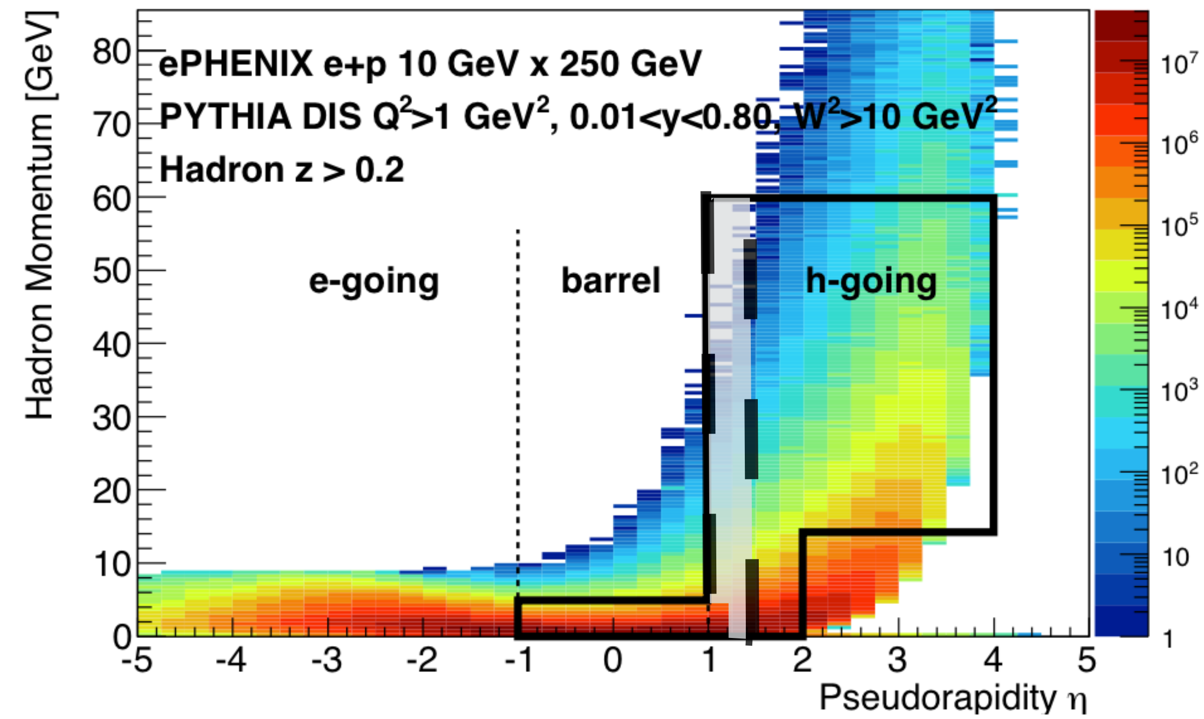


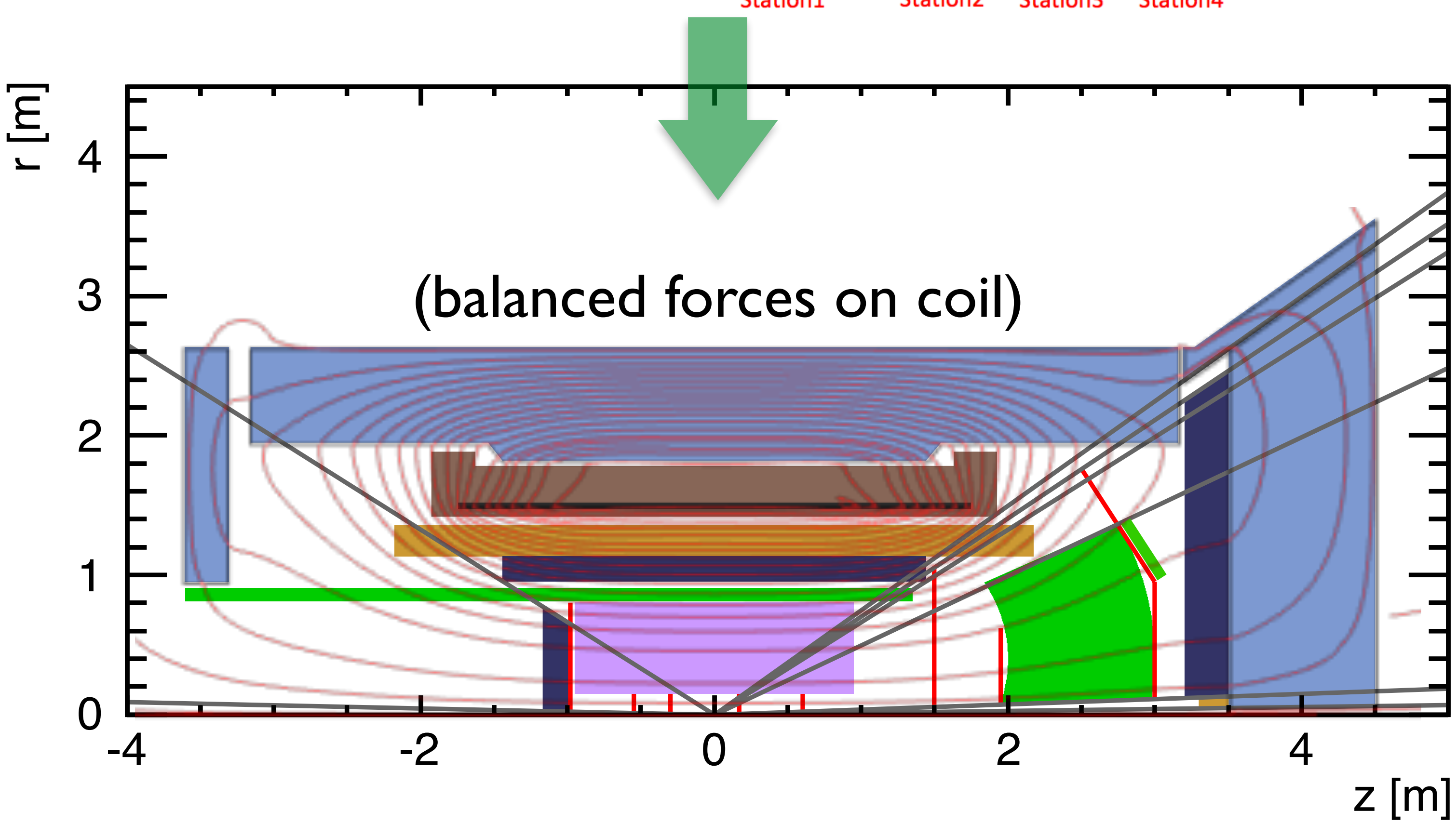


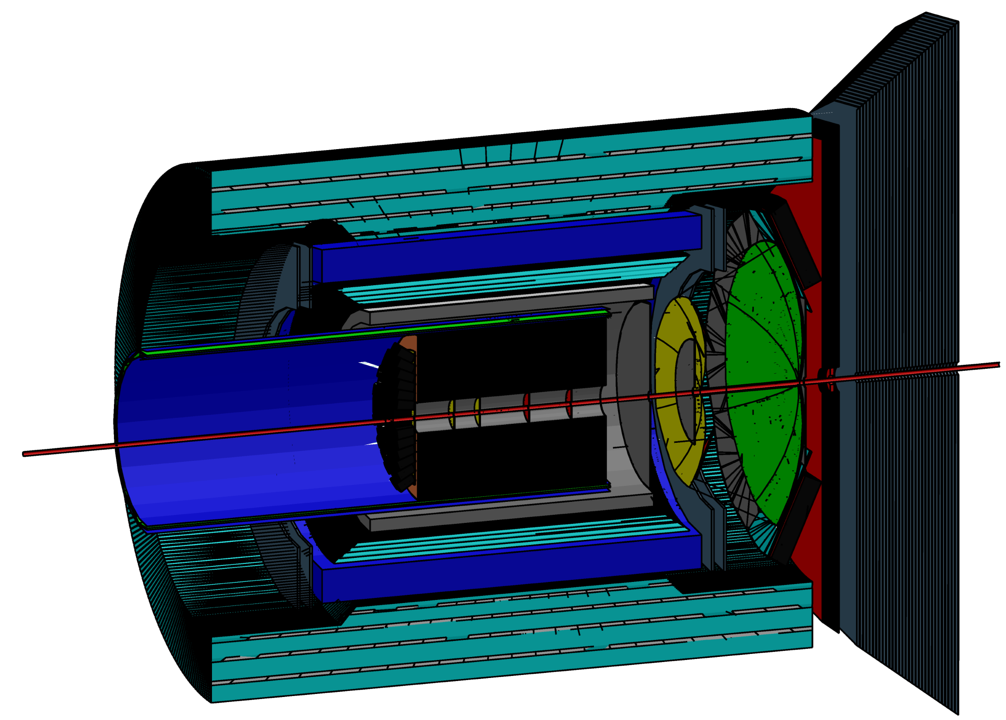
arXiv:1402.1209v1

What has happened since the LOI?

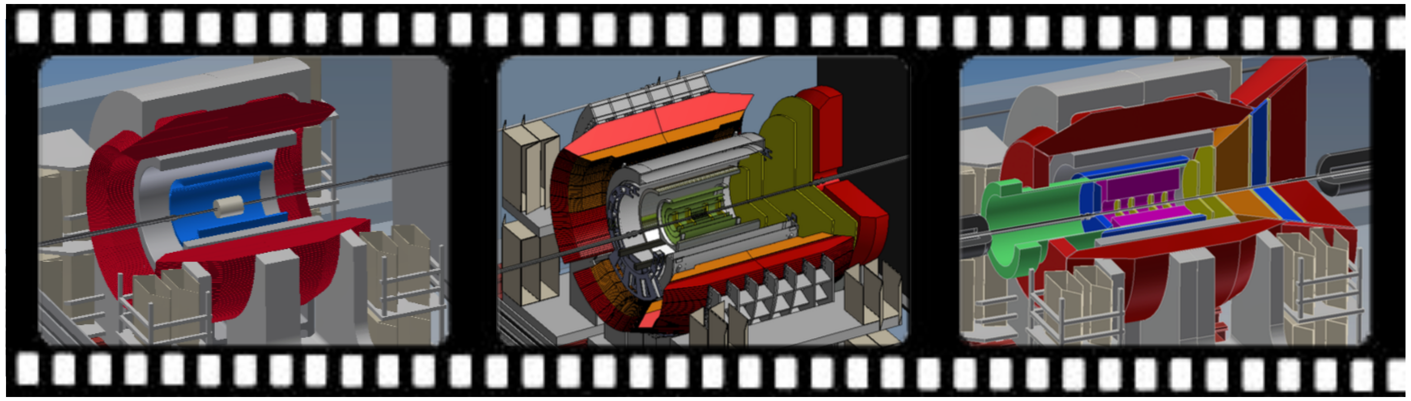








Summary

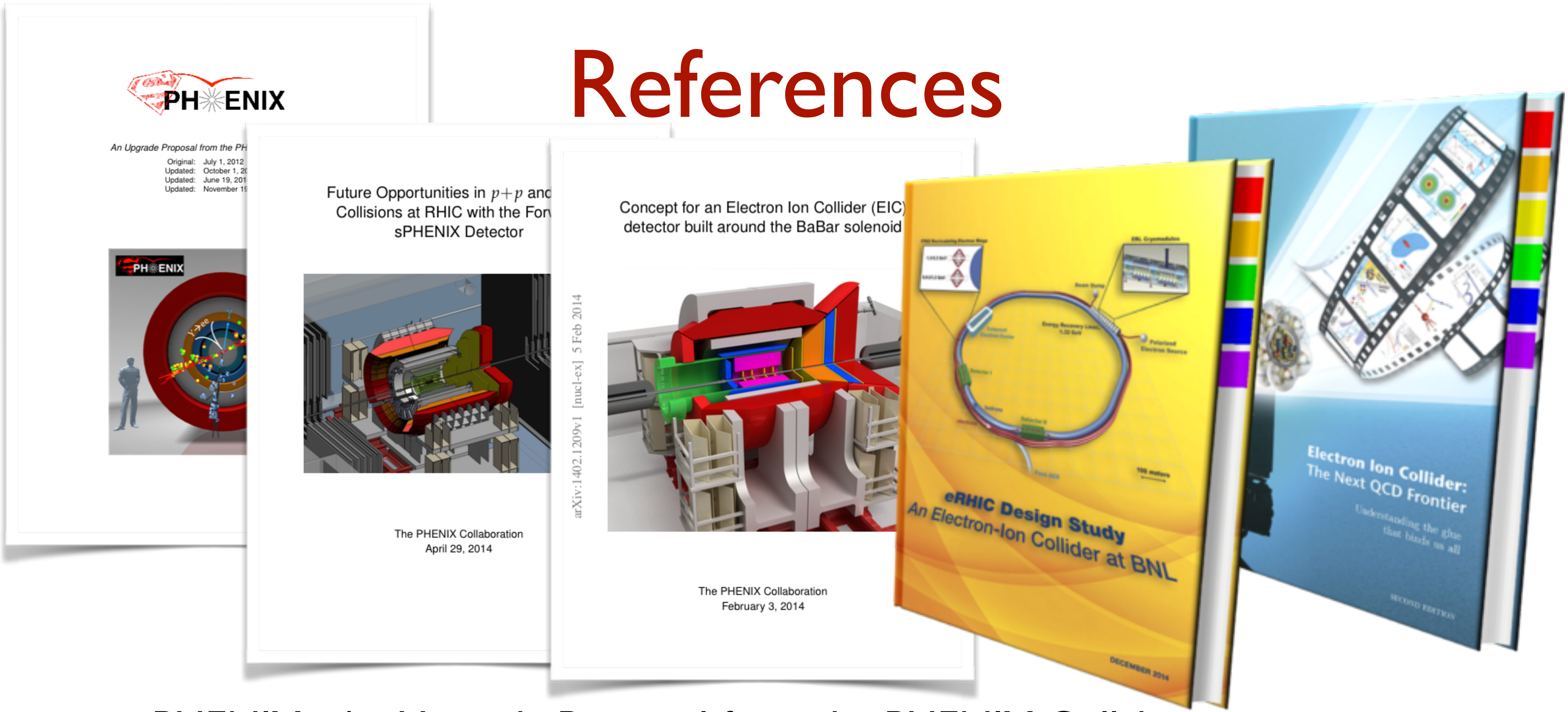


- Ongoing simulation and hardware activities push the detector design, incorporate sPHENIX updates, and offer a lot of opportunity for collaboration.
- Continuous contact with MEIC detector group in meetings and discussions explores synergies (e.g. RICH) and option to use this detector at MEIC.

sPHENIX can naturally evolve (via fsPHENIX?) into an EIC detector that covers all critical acceptances and will do the essential Day1 Physics.

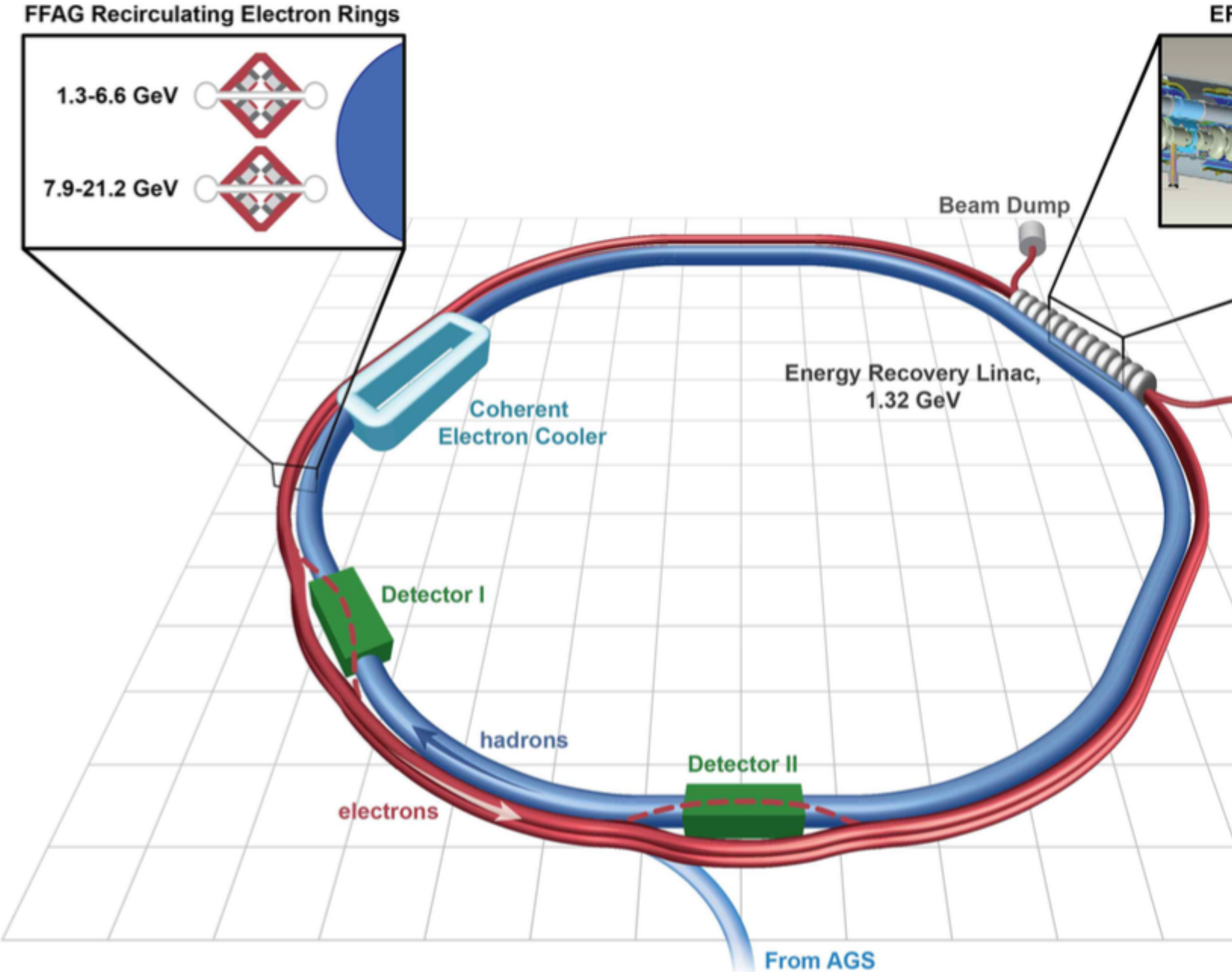
ADDITIONAL SLIDES

References



- ➡ sPHENIX - An Upgrade Proposal from the PHENIX Collaboration
- ➡ Future Opportunities in p+p and p+A Collisions at RHIC with the Forward sPHENIX Detector
- ➡ Concept for an Electron Ion Collider (EIC) detector built around the BaBar solenoid [arXiv:1402.1209v1]
- ➡ Electron Ion Collider: The Next QCD Frontier [arXiv:1212.1701v3]
- ➡ eRHIC Design Study [arXiv:1409.1633]

e+p / e+A Collisions at RHIC



Energy:

- Electron: 6.6–21.2 GeV
- Proton: 25–250 GeV
- Ions: 10–100 GeV
- $\sqrt{s}$: up to 145 GeV

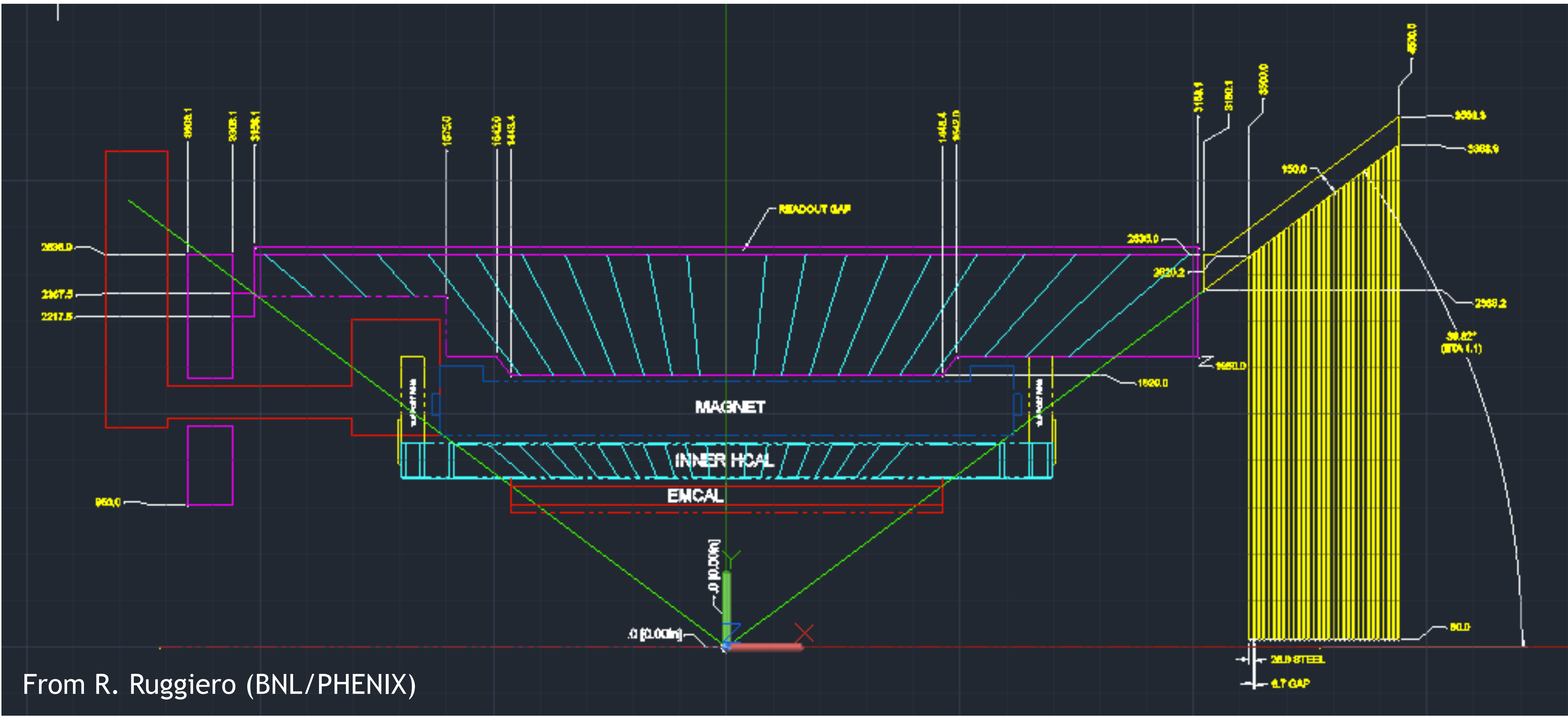
Polarization:

- Electrons: 80%
- Protons and He3: 70%

Luminocity:

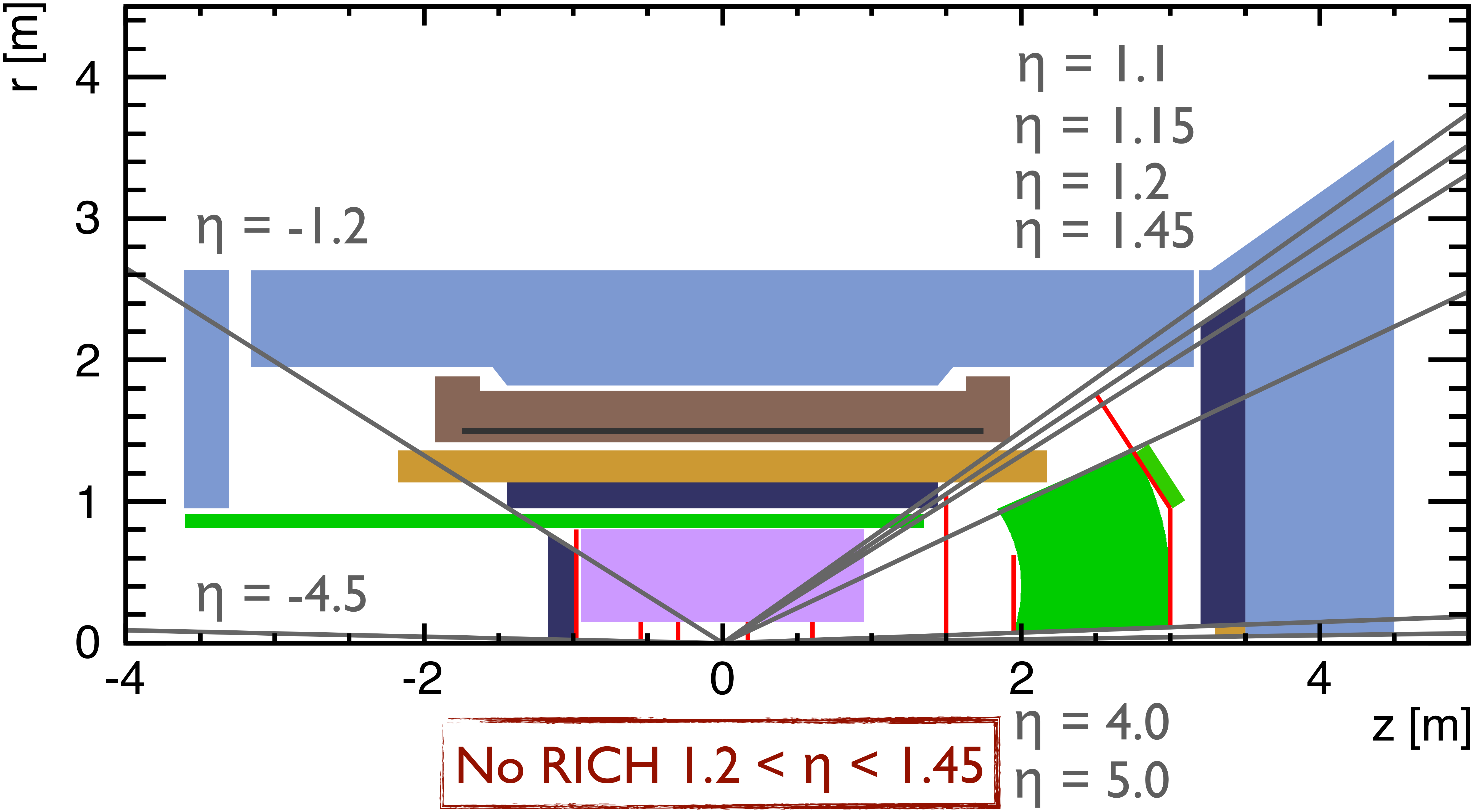
- $>10^{33}$ cm^{-2} s^{-1}

Updated mechanical design for EIC Detector / fsPHENIX



From R. Ruggiero (BNL/PHENIX)

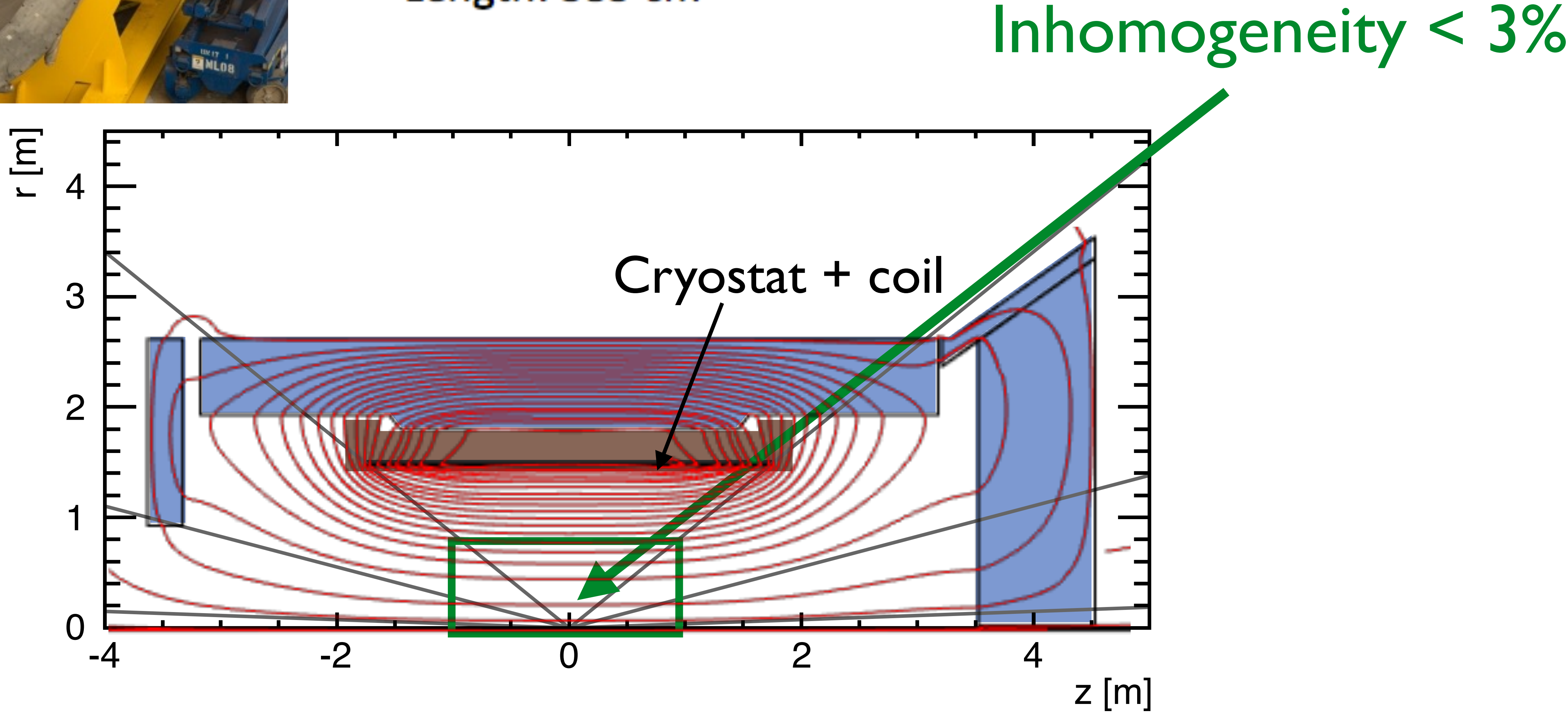
sPHENIX Geometry Updates



No RICH 1.2 < η < 1.45

The Central Element: The BaBar Coil

- ✓ Superconducting Solenoid
- ✓ Field: 1.5T
- ✓ Inner radius: 140 cm
- ✓ Outer radius: 173 cm
- ✓ Length: 385 cm

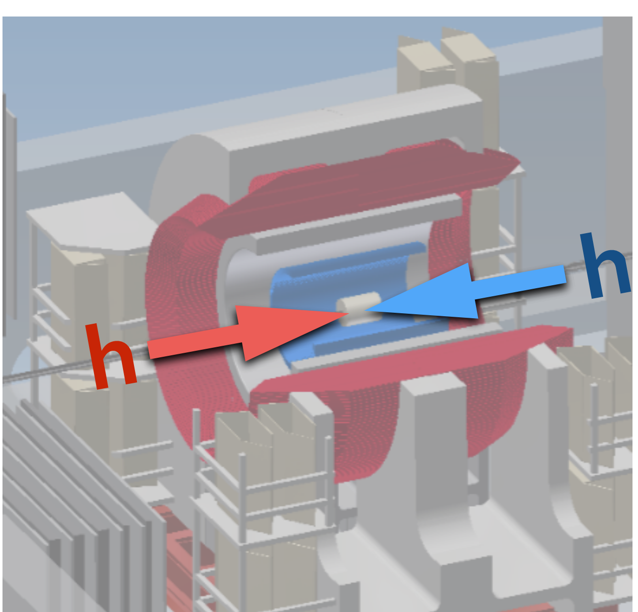


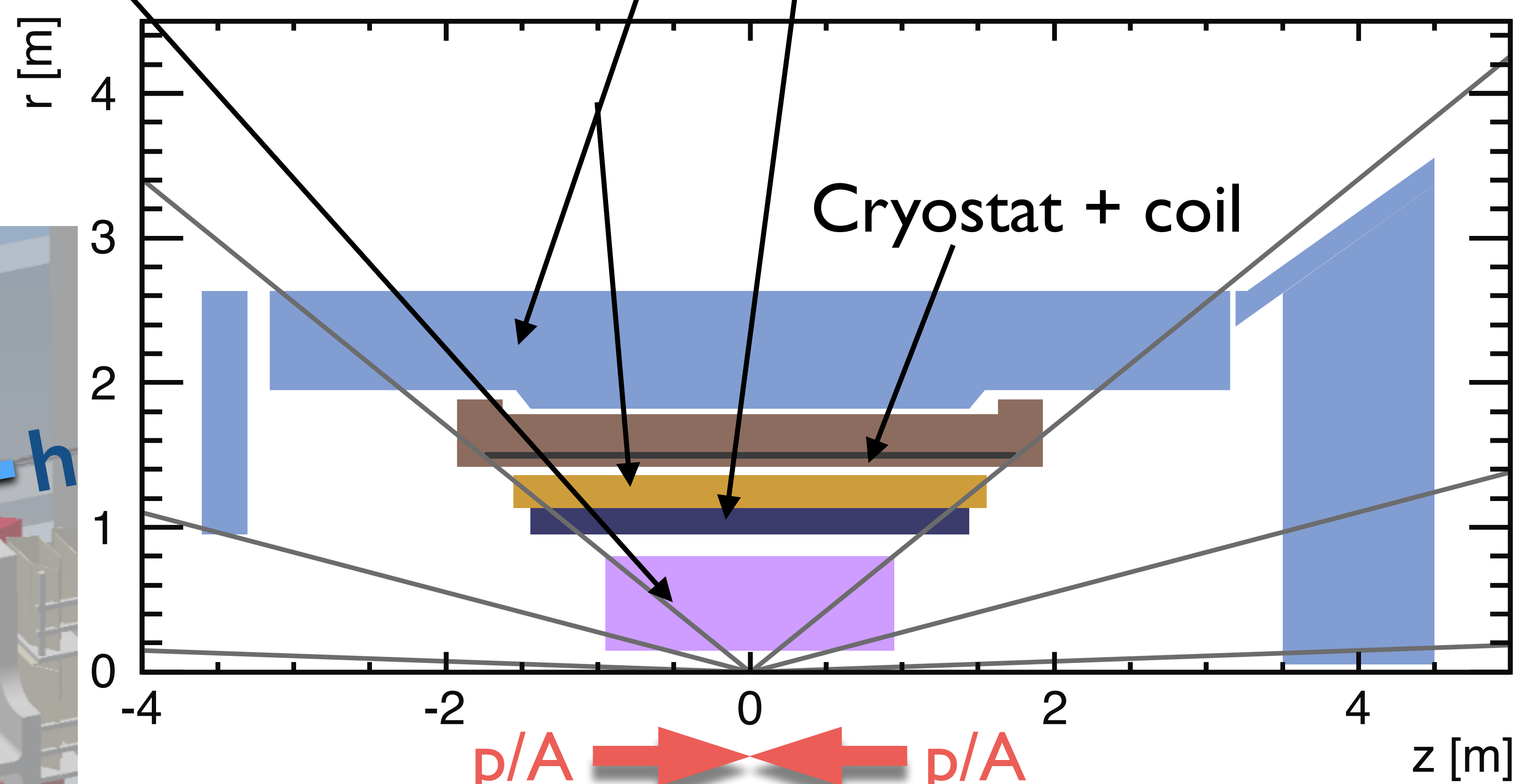
sPHENIX

Tracking
- 2 layer Silicon vertex pixel
- 5 layer Silicon-strip OR TPC

$$\frac{\Delta p_T}{p_T} = 0.0107 + 0.000267\, p_T$$

- HCAL: Steel-scintillator (5 λ_{int})
  100%/$\sqrt{E}$ energy resolution
  $\eta \times \varphi \sim 0.1 \times 0.1$ segmentation
- ECAL: Tungsten-scintillating fiber (18 X_0)
  12%/$\sqrt{E}$ energy resolution
  $\eta \times \varphi \sim 0.024 \times 0.024$ (2x2 cm^2) segmentation

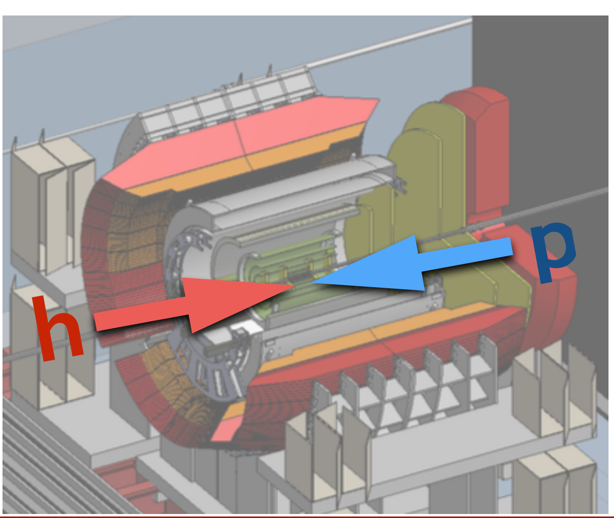


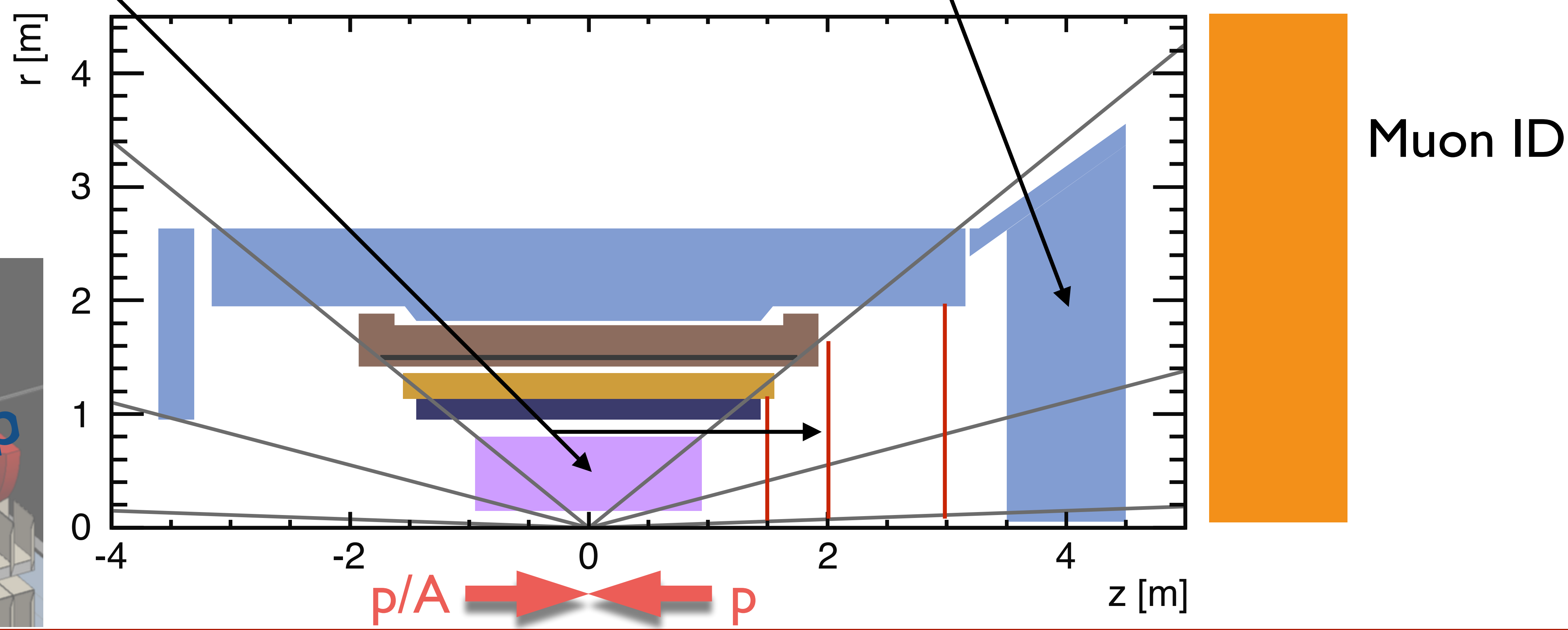


fsPHENIX

Tracking
- 2 layer Silicon vertex pixel
- Silicon-strip OR TPC
- FVTX
- GEM ($r\delta\varphi$ resolution ~100μm)

Hadron Calorimeter
- Steel-scintillator (5 λ_{int})
  100%/$\sqrt{E}$ energy resolution
  ~ 10 × 10 cm^2 segmentation

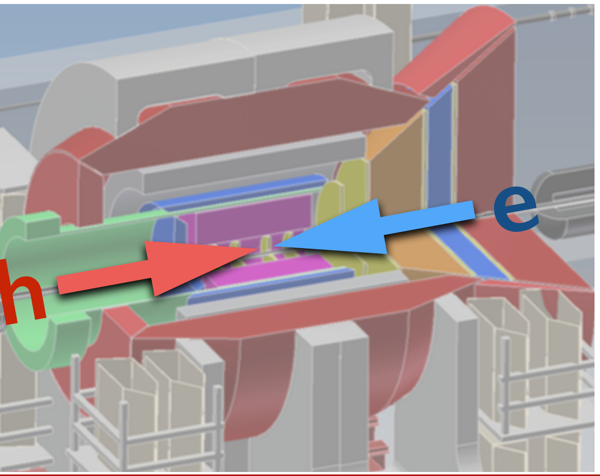


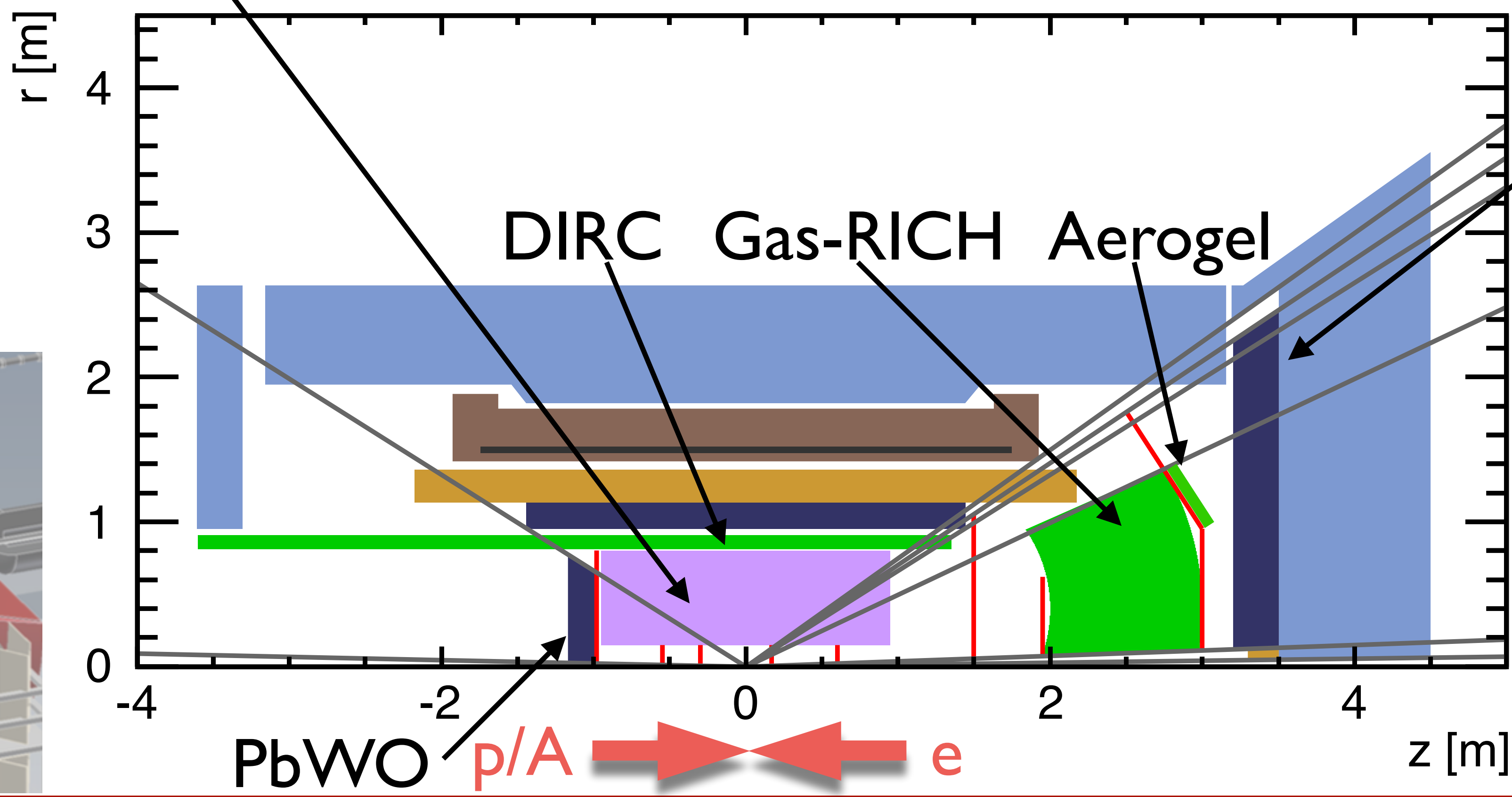


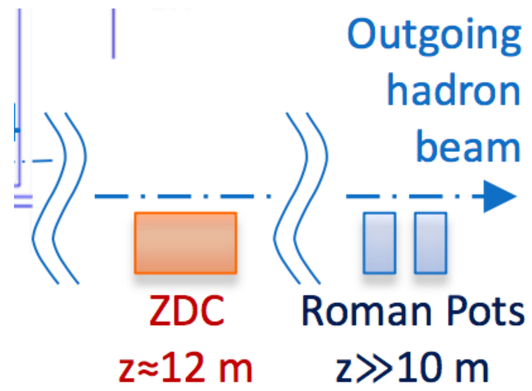
EIC Detector Built Around the BaBar Solenoid

Tracking
- TPC (300 μm position resolution)
- GEMs (50-100 μm resolution in $r\Delta\varphi$)

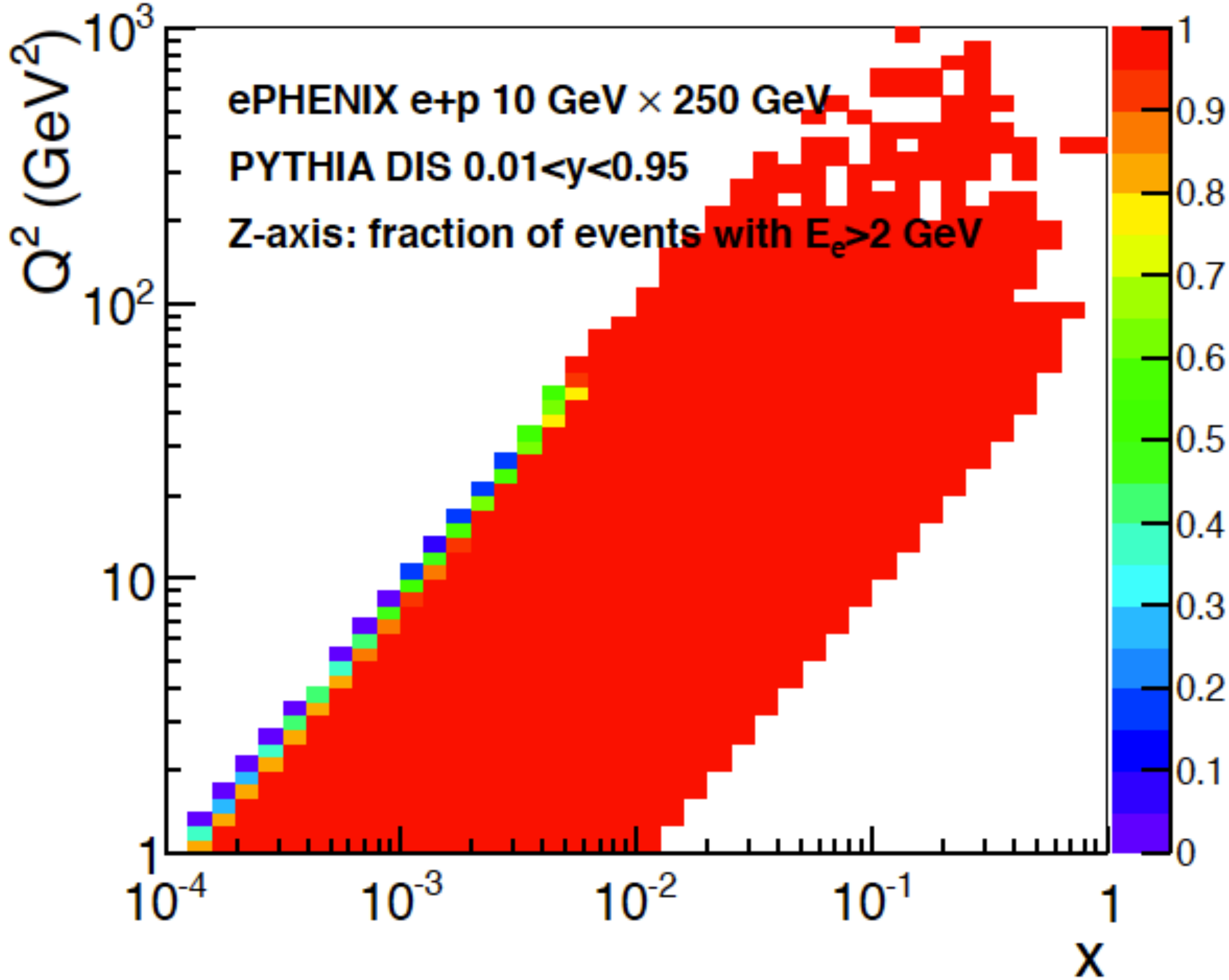
Electromagnetic Calorimeter
- Lead-tungstate (20 X_0)
  1.5%/√E energy resolution
  3mm/√E position resolution
- Lead-scintillator (18 X_0)
  12%/√E energy resolution
  ~3x3 cm^2 segmentation



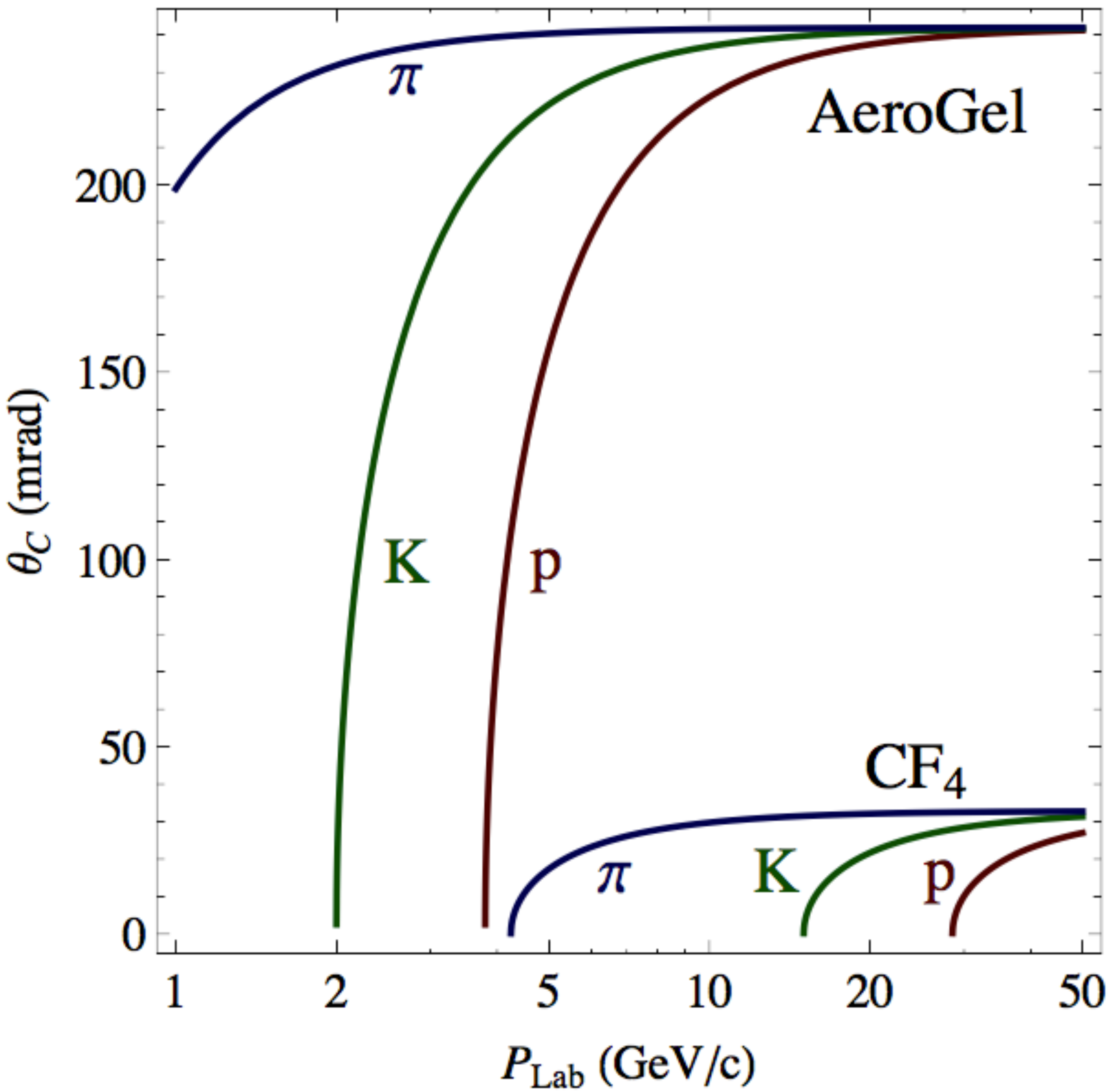




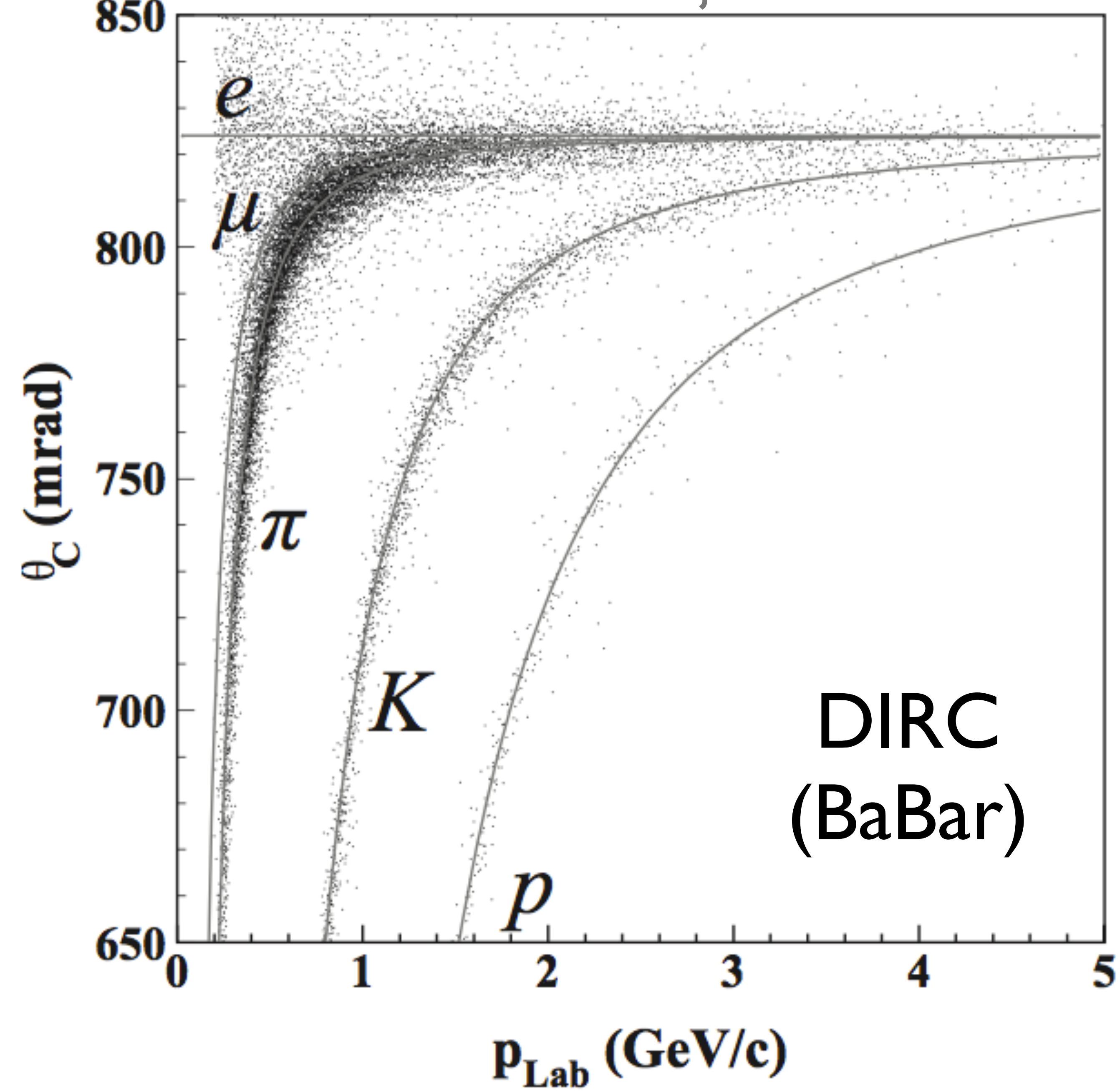
Electron Selection Efficiency



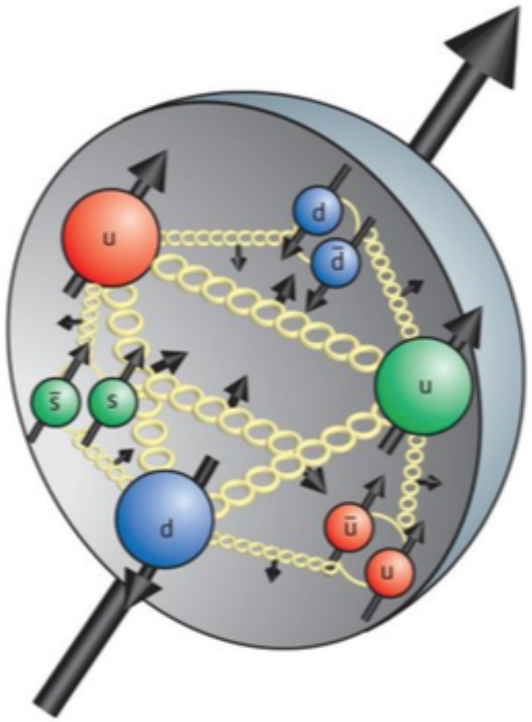
Hadron ID Performance for EIC



doi:10.1016/j.nima.2004.08.129

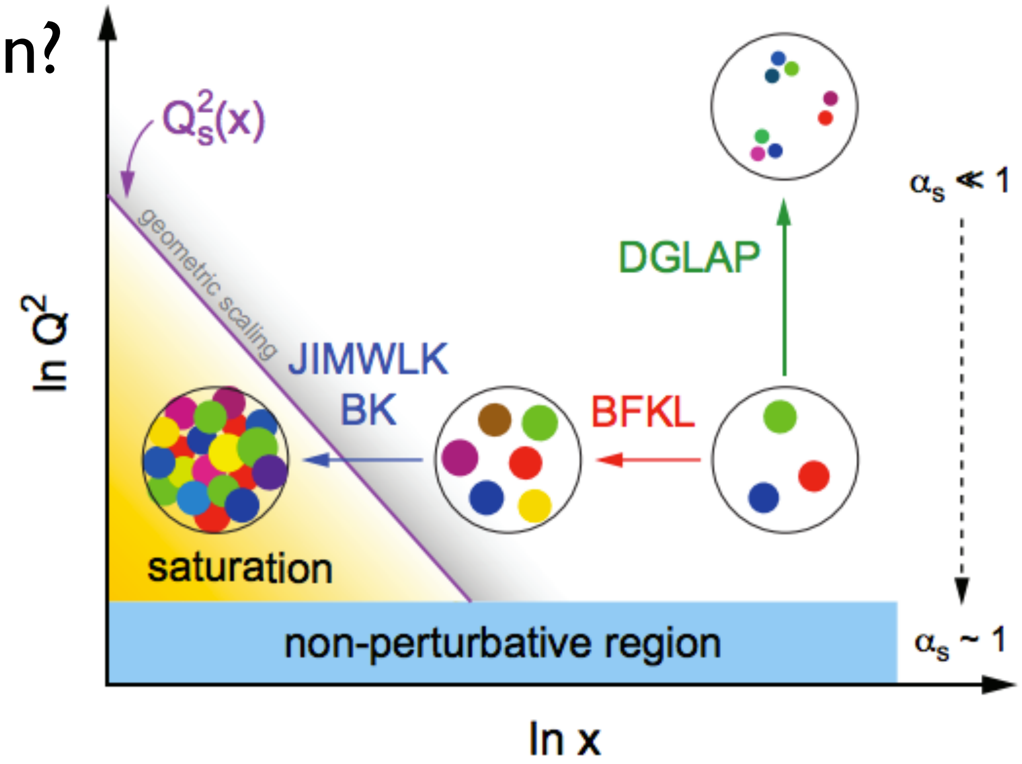


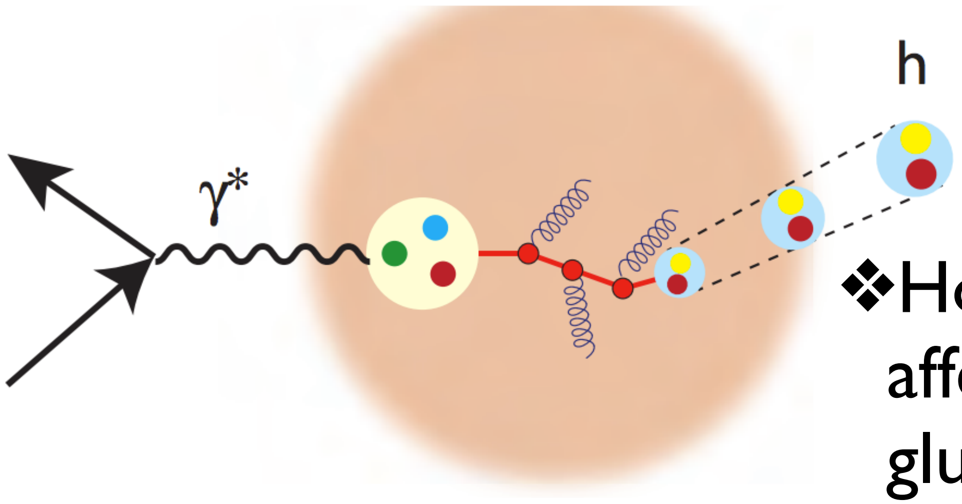
"A Bridge Between Quarks / Gluons And Nuclei"



❖How are the sea quarks and gluons, and their spins, distributed in space and momentum inside the nucleon?

❖Where does the saturation of gluon densities set in?

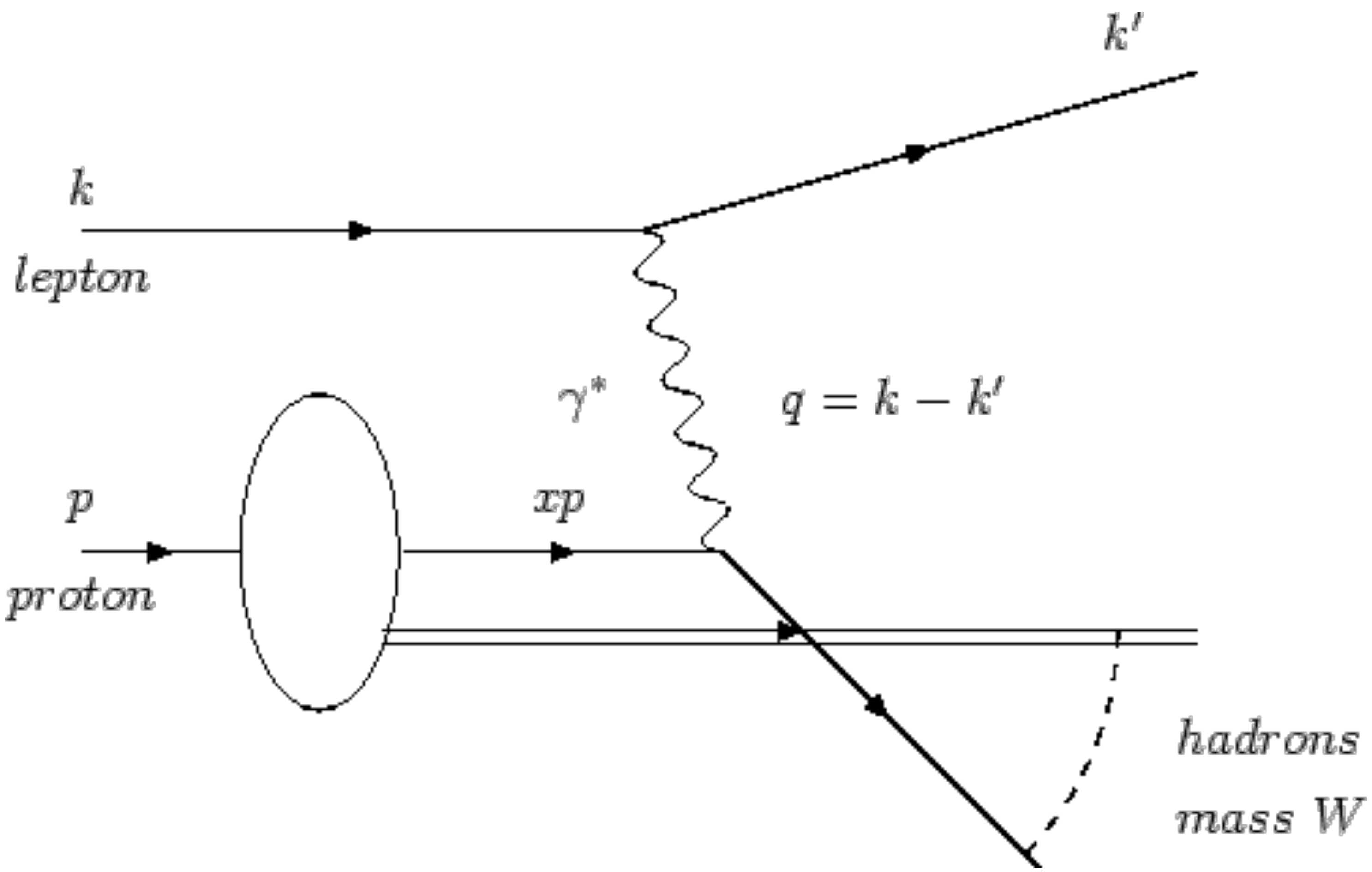




❖How does the nuclear environment affect the distribution of quarks and gluons and their propagation?

arXiv:1212.1701v3

Deep Inelastic Scattering (DIS)



s = collision energy (squared)

$Q^2 = -q^2 = -(k - k') =$ momentum transfer / resolution

x = momentum fraction of struck quark

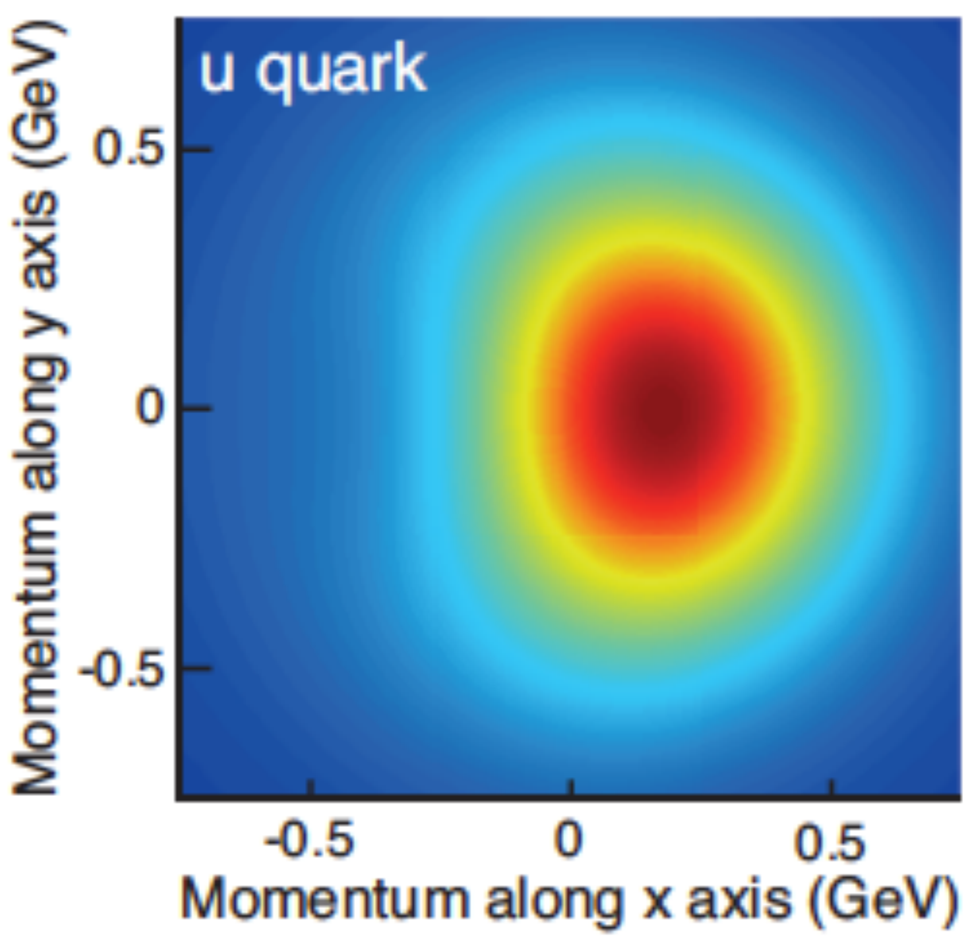
$y = (q\,p) / (k\,p)$ = inelasticity

Relation: $Q^2 = s\,x\,y$

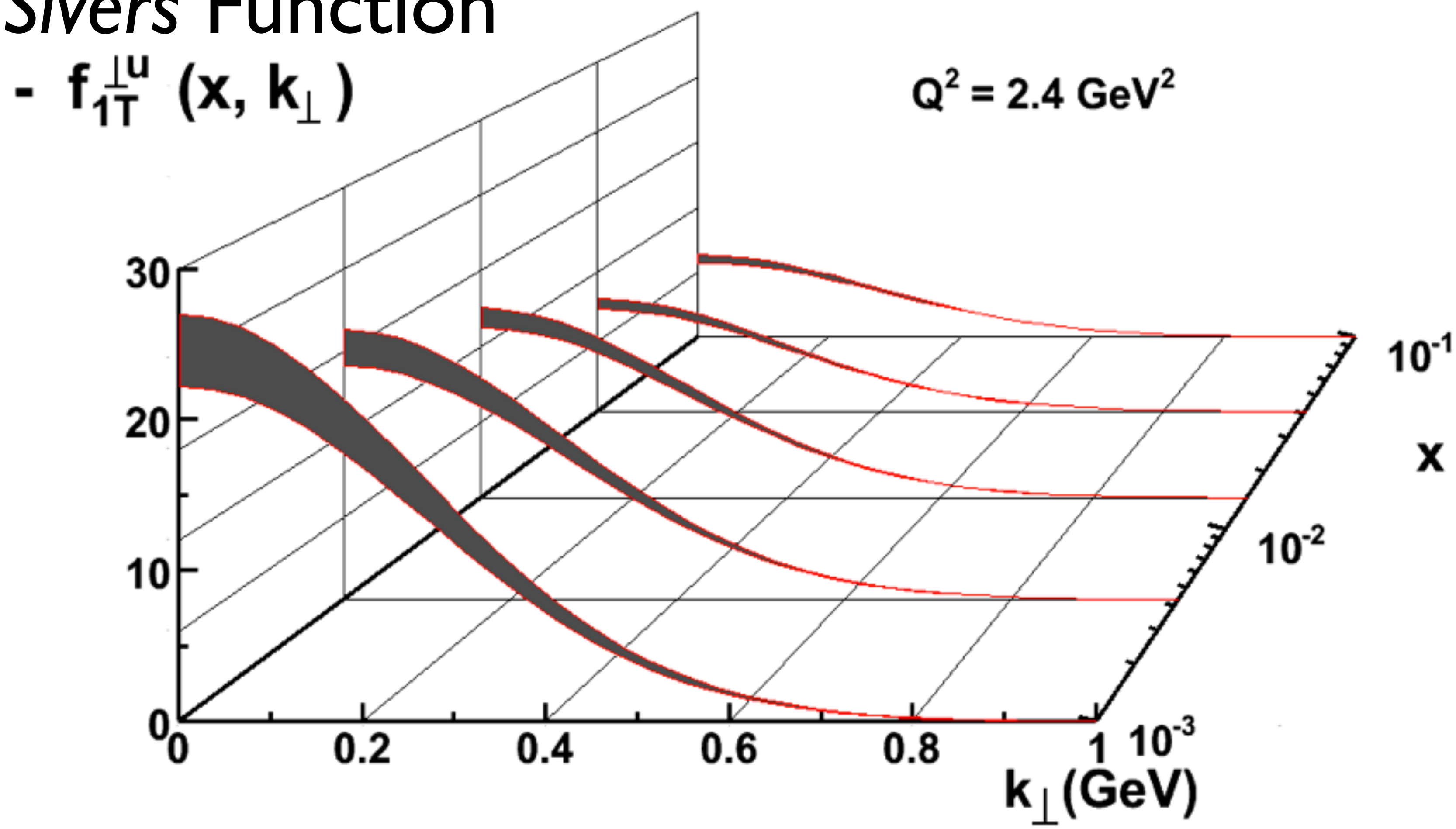
$z = (P_h\,P) / (q\,P)$ = momentum fraction of the final state hadron with respect to the virtual photon

W^2 = squared invariant mass of the produced hadronic system

SIDIS: Transverse Momentum Dependent Parton Distributions

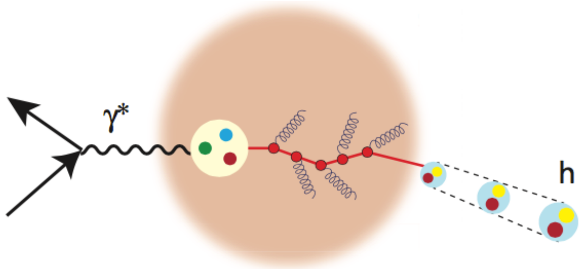


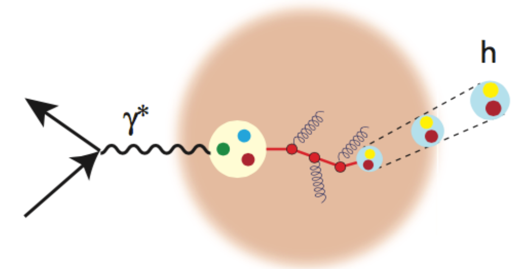
Sivers Function

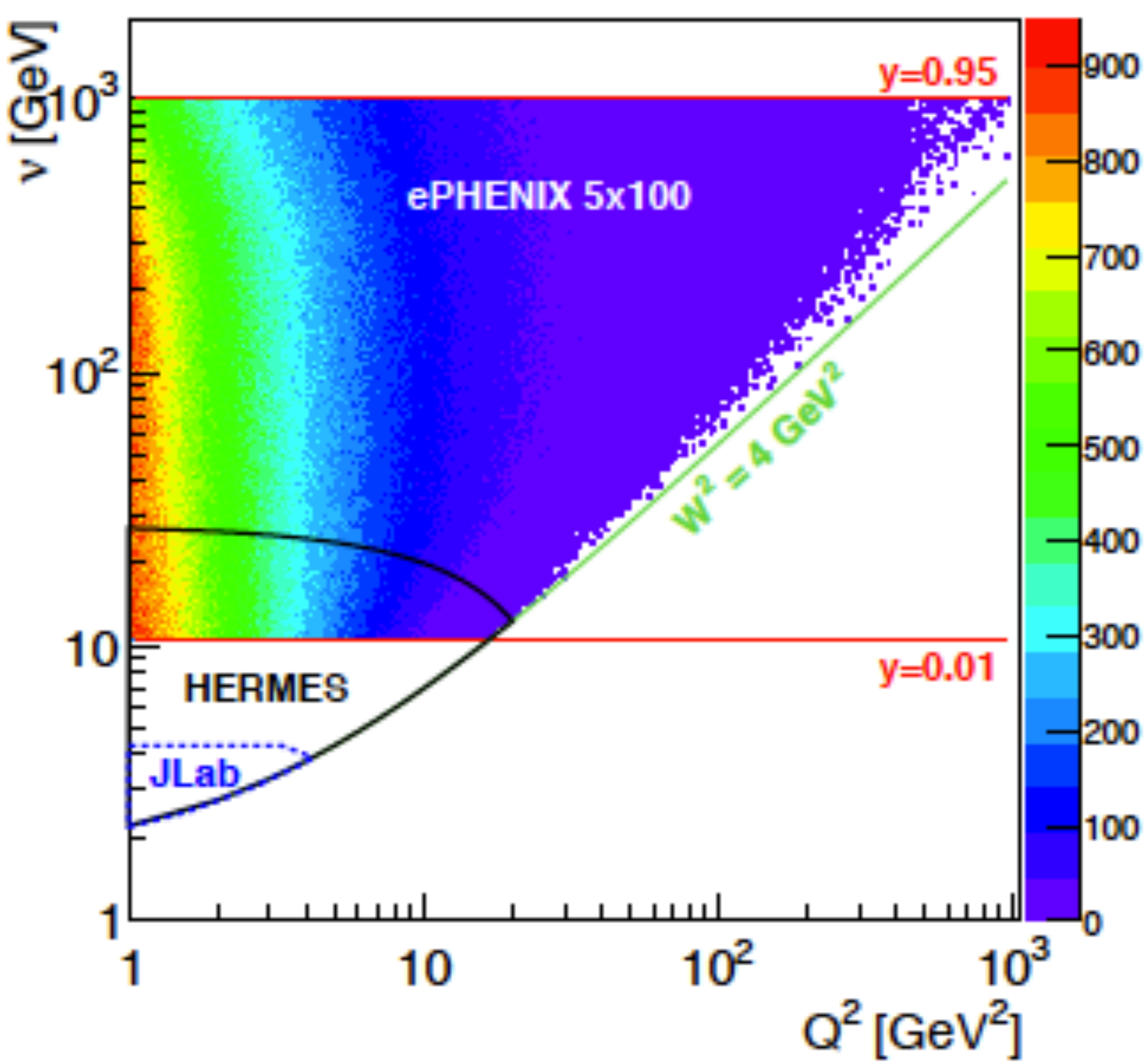


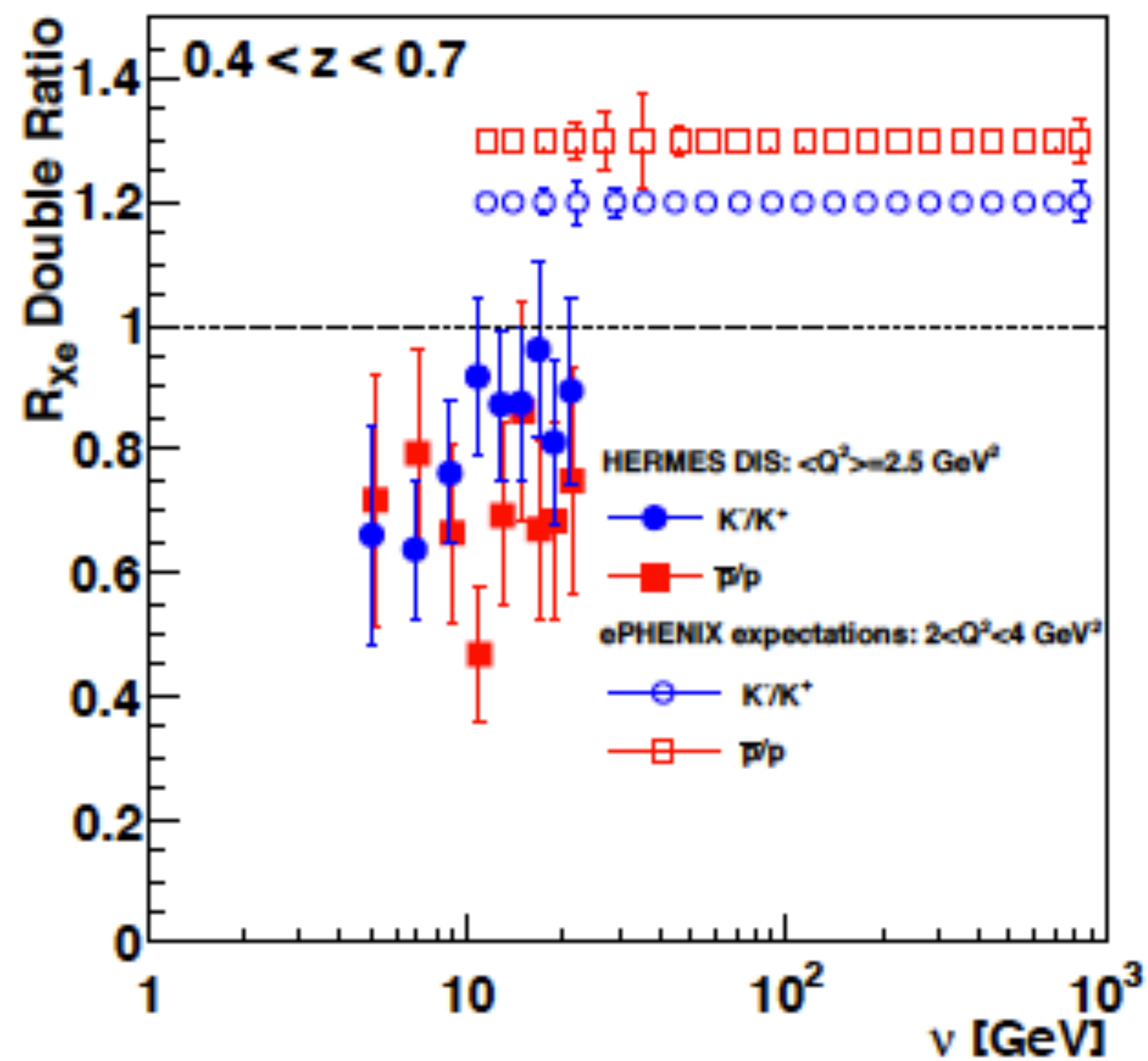
arXiv:1212.1701v3

e+A Physics









arXiv:1402.1209v1